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ART. I.—*Kaolinised Granodiorite in the Bulla-Broadmeadows Area.*

By A. J. GASKIN, M.Sc.

[Read 13th May, 1943; issued separately 1st August, 1944.]

Abstract.

The evidence provided by the chemical and mineralogical composition and the field occurrence of the kaolinised granodiorite is examined with a view to determining the most probable mode of origin of the deposits. The evidence now available, though inconclusive in itself, suggests that the kaolinising agencies might have been associated with the extrusion of the Tertiary basalts.

Introduction.

The occurrence of kaolinised granodiorite in the Bulla-Broadmeadows area has been noted by Dunn (1899), Armitage (1911), Stillwell (1911), and James (1920). The nature of the process which has given rise to irregular patches of kaolinised granodiorite, scattered over the surface of an otherwise normal intrusion, has been the subject of much discussion. Dunn and Armitage believe that the kaolin was produced by the action of meteoric waters, whilst Stillwell and James suggest that pneumatolysis was more probably responsible for the kaolinisation.

The most complete review of the evidence relating to the cause of kaolinisation was given by James (1920), who concluded that microscopical examination of the kaolinised material gave no definite evidence in favour of either of the above theories, but that " the field evidence, while producing little positive evidence in support of pneumatolysis, strongly discounts the meteoric theory."

The present paper contains the results of an examination of the physico-chemical characteristics of the kaolinised felspar and the associated minerals in an attempt to deduce the nature of the conditions under which kaolinisation took place. The evidence relating to the field occurrence of the altered material is then re-examined in order to decide the most probable way in which these conditions were brought about.

Field Occurrence of the Deposits.

GRANODIORITE.

The granodiorite outcrops in the Bulla district are so closely related, both chemically and mineralogically, to the neighbouring outcrops in the Broadmeadows district, that there is no reason to doubt the suggestion that they are both portions of the same igneous intrusion. Although chemical analyses quoted by James (1920) suggest that the granodiorite at Bulla contains slightly less potash and slightly more lime than the corresponding rock from Broadmeadows, and the orthoclase-plagioclase ratio of the latter caused Stillwell (1911) to term it an adamellite, the distinction has no significance as far as the present investigation is concerned.

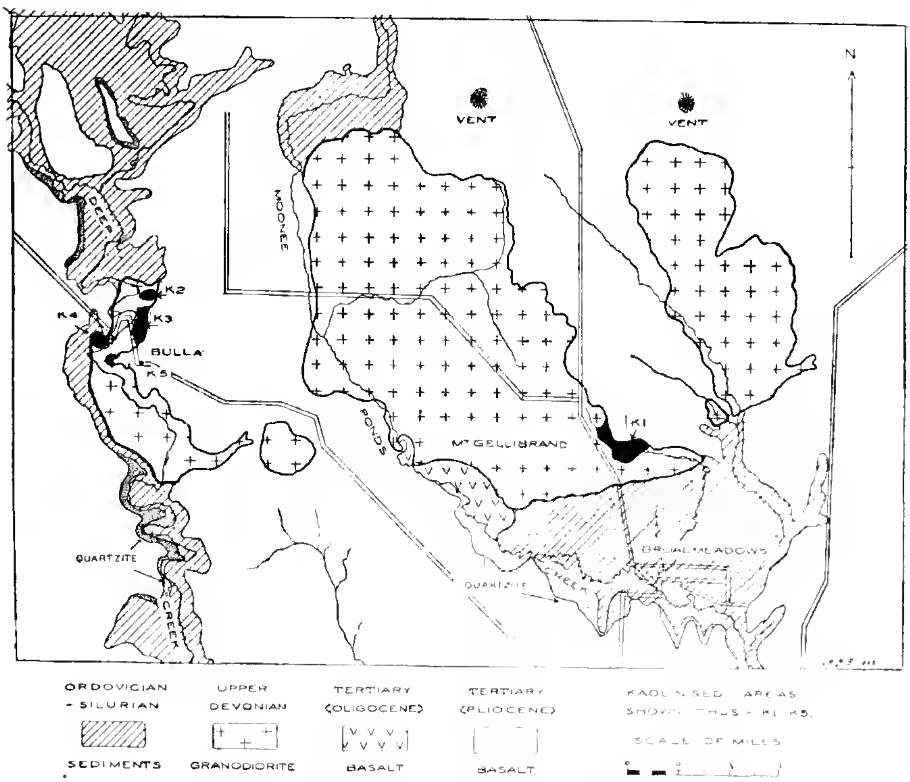
The geological map appended to this paper (p. 3) is based on a combination of the maps of Stillwell (1911) and James (1920), together with portions of Quarter Sheets 2 and 7 of the Geological Survey. It shows the Bulla-Broadmeadows intrusion as a stock-like body, elliptical in plan, extending about seven miles along its E.-W. axis, and about four miles along its N.-S. axis. On its northern, western, and southern boundaries, it junctions with contact metamorphosed Silurian and Ordovician sediments. Because of its analogies to similar granodiorites in Central Victoria, it is probable that the intrusion is of Upper Devonian age. The intrusion was exposed by erosion prior to the Tertiary, portion of it being covered during that period by fluviatile conglomerates, which were later covered by the basalts of the Older Volcanic series. Extensive lacustrine deposits separate portions of the Older Volcanic from the Newer Volcanic flows, a series of which have been extruded from vents near the western and northern boundaries of the area shown in the map (p. 3). The basalts of the newer Volcanic series extend across the granodiorite in two parallel tongue-like flows, leaving the central and two outer portions of the intrusion exposed as inliers standing up above the basalt flood. Post-Newer Volcanic erosion has exposed much of the western portion of the granodiorite that was originally covered with basalt.

KAOLINISED GRANODIORITE.

At Bulla, where the basalt has been removed by erosion, extensive outcrops of kaolinised granodiorite have been exposed, but no kaolinised granodiorite occurs above the surface level of the basalt.

It is not possible to trace definite connexions between the various kaolin outcrops here, since they are now separated by the valley of Deep Creek. There is a possibility that most of the present outcrops were originally joined to form a single large body of kaolinised material. However, the ridge of fresh granodiorite separating the kaolinised outcrops west of Deep Creek

(K4), from those to the east of the stream (K2, K3, K5) rises almost to the level of the basalt, so that any former connection between these two main kaolin deposits must have been but a shallow layer at the surface.



Geological Sketch Map of the Bulla-Broadmeadows Area.

Kaolinised granodiorite occurs at a high level (420 ft.) and at a low level (300 ft.), the maximum depth of kaolinisation in any single outcrop being about 90 ft., judging from the cliff exposures (K2) immediately to the north of the main bridge over Deep Creek. At this place, the kaolinised material at the bridge level is fresher in appearance than that at higher levels in the cliff, being blue-grey in colour, and containing numerous flakes of unaltered biotite and fragments of cloudy felspar. Completely kaolinised granodiorite can be observed to overlie fresher material in the valley wall of Deep Creek, where fresh granodiorite is

exposed at a spot 20 ft. below and 20 ft. to the west of, the floor of the kaolin quarry (K5) on the side road to Bulla School. About 60 feet of kaolinised granodiorite overlies fresh granodiorite in the gully (K4) across the creek from the school.

The upper surface of the kaolinised granodiorite is extremely well defined in some instances, the clean upper surface of the kaolin being in direct contact with the lower surface of the basalt. In other instances, 10 to 20 ft. of ferruginous grit and sand overlie the kaolinised material and are overlain by basalt. The latter has given rise to some silicification of the grits, converting them in part into quartzites. In the main road cutting at Bulla (near K3), the grits and sands contain small boulders of kaolinised and partially silicified granodiorite up to 6 inches in length, and markedly angular in form, showing facets, edges, and blunt points.

At Broadmeadows, a recently developed quarry (K1) in kaolinised granodiorite on the east flank of Mount Gellibrand was extending rapidly to the west and south when operations were suspended because of the war. The lateral extent of the kaolinised material is as yet unknown because of the thick soil covering to the east, west and south of the quarry. The kaolin is covered by basalt to the north and north-east, but can be traced round the boundary of the flow for several hundred feet to the north-west. The floor of the quarry is in kaolinised granodiorite at a level 20 ft. below the surface. Although the rock has been kaolinised for a distance of several hundred feet to the south of the basalt contact, the upper surface of the kaolinised material is, as at Bulla, below the upper surface of the basalt. In the main face of the quarry, the kaolinised material is divided into two parts by a vertical dyke-like body, containing only fine-grained quartz and kaolinite. The material is distinct from the surrounding kaolinised granodiorite, its appearance suggesting kaolinised quartz porphyry. The "dyke," which appears to strike approximately north-south, is from 10 to 20 ft. in thickness, and is exposed in the floor of the quarry for a distance of 40 ft. to the north, where it disappears under the basalt. Any southerly continuation is obscured by a thick soil layer. The contact between the dyke and the granodiorite is sharply defined, indicating that the intrusion of the dyke took place subsequent to the consolidation of the granodiorite and before the kaolinisation of the latter.

Extrusives.

In the area, the basaltic flows of the Newer Volcanic series can be divided into two groups, which James (1920) has termed the Upper and Lower series. At one place on the Sunbury-road, at the top of the rise from Bulla township, kaolinised granodiorite

is covered by a thin flow of basalt belonging to the Lower Series. The flow is honeycombed with vesicles up to an inch in length, indicating the presence of an abundance of gaseous material at the time of extrusion. A thicker flow of dense massive basalt, belonging to the Upper series, overlies this thin vesicular flow. Because of the absence of distinguishing characteristics which could be used to classify the various flows, there is as yet no consistent evidence connecting the occurrence of kaolinised granodiorite with any particular flow or group of flows.

Composition of the Deposits.

Clay Minerals.

In the hand specimen and under the microscope, there are no significant differences to be found in the appearance of samples of kaolinised granodiorite from any of the Bulla-Broadmeadows outcrops, with the sole exception of the material from the kaolinised " dyke " in the Broadmeadows Quarry, the fine-grained character of which suggests that quartz porphyry rather than granodiorite was the parent rock.

Thin sections show the normal kaolinised granodiorite to be composed of large (5-10 mm.) quartz grains, set in a matrix of kaolinite, bleached biotite, and muscovite, with minor amounts of zircon, calcite, and apatite.

The clay mineral, which is the most abundant mineral in the sections, occurs in irregular patches composed of book-like aggregates of minute flakes. These aggregates are elongated in the direction of the normal to the plane of basal cleavage, several of the more elongated " books " showing the sinuous curves of the characteristic " worm-like " aggregates of kaolinite described by Ross and Kerr (1930). Where the individual flakes are large enough to be observed, they show straight extinction, low birefringence, and a mean refractive index of 1.566. Indistinct interference figures suggest an optic angle (2V) of about 20°, the character being negative.

Since the minute grain size of the clay fraction militated against exact identification by optical means alone, the physical properties of the material were further investigated, as the exact identification of the predominant clay mineral has an important bearing on the problem of the nature of the conditions prevailing during the alteration of the granodiorite. The further properties on which the identification of the clay minerals was based were:

(i) chemical composition

(ii) dehydration curve

(iii) adsorptive properties

(iv) crystal structure.

(i) Chemical Analysis of the Clay Fraction.

Table II., Column IV., shows an analysis of the clay separated by sedimentation from the Bulla kaolinised granodiorite. The analysis suggests that a mineral of the kaolinite group forms the greater part of the material. The considerable amount of water expelled below 110°C. suggests that an appreciable amount of halloysite was present, as Ross and Kerr (1934) have shown that minerals of the halloysite type are capable of holding somewhat more water by " mechanical " bonds than are minerals of the kaolinite type. The proportion of halloysite to kaolinite indicated by the analysis (and in the dehydration curve) is, however, greater than that which prevailed in the samples as they were originally collected. This is a result of the sedimentation treatment necessary to remove quartz and mica, a portion of the kaolinitic clay fraction being separated in flake-aggregates which settle rapidly and are discarded with the fine quartz fraction.

(ii) Dehydration of the Clay Fraction.

The various clay minerals of the kaolinite group lose their combined water at different and characteristic temperatures (Ross and Kerr, 1930). A check may thus be made on an identification by plotting the dehydration curve of the clay mineral. The clay fraction concerned in the present investigation showed a small, continuous loss of water between 110° and 450° (see fig. 1). At the latter temperature, a sudden loss in weight occurred, as is exhibited by kaolinite, little further loss occurred between 500° and 800°, so that it may be assumed that dickite and nacrite were not present in appreciable quantities.

(iii) Adsorptive Properties of the Clay Fraction.

After separation from the altered granodiorite by sedimentation, the clay-fraction was treated with methylene blue to determine its adsorptive properties, and with malachite green to determine its base exchange capacity. The procedures are similar to those described by Faust (1940).

Methylene Blue.—About 0.1 gram of the clay fraction was agitated in a 1 per cent. aqueous solution of the dye, until no more dye was removed from the solution, which was then filtered off, the stained mineral being air-dried and examined under the microscope. All of the kaolin in the altered rock from Bulla and Broadmeadows was found to adsorb the dye strongly, the individual flakes being stained an intensely deep blue. When partially stained, the flakes retained a slight transparency and were feebly pleochroic from light to dark blue. The blue-grey polarisation colours of the flakes (viewed normal to the basal plane) appeared to be raised on staining to second order reds, as

described by Bosazza (1940). The colour appears to be distinct from the reddish reflection tint which the dye imparts to the surfaces of the flakes.

The above staining treatment established the clay mineral as kaolinite, as distinct from dickite and nacrite, which do not adsorb the dye to any appreciable extent. Montmorillonite and its analogues are not distinguished from kaolinite by this test, but show characteristic behaviour when treated with malachite green.

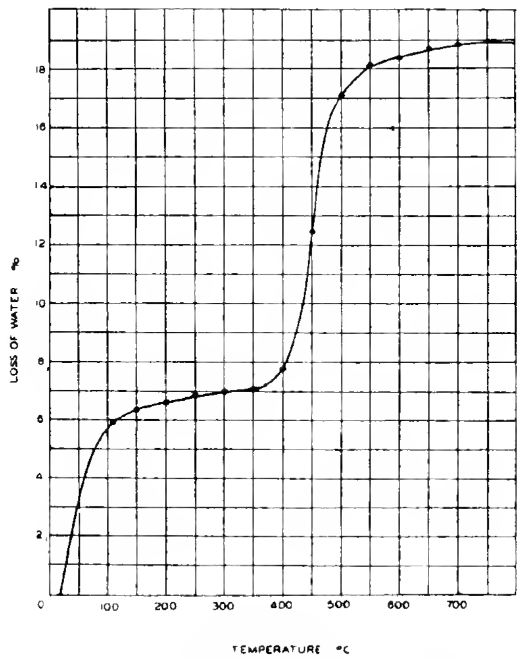


Fig. 1.—Dehydration Curve of Kaolin Mineral obtained from Kaolinised Granodiorite, Bulla (K 3).

Malachite Green.—The clay fraction was suspended in boiling dilute HCl for two hours, after which the acid was removed by filtration, and the residue washed free from acid. The washed mineral was then treated with a 1 per cent. neutral aqueous solution of malachite green, filtered, and allowed to dry. During such an acid treatment, clay minerals with replaceable cations form hydrogen substitution products which, when treated with the dye, inhibit the dissociation of the adsorbed malachite green. The particles are thus stained the yellow colour characteristic of the undissociated dye molecules. The clay mineral from the Bulla-Broadmeadows deposits showed behaviour characteristic of

the minerals of the kaolin group, i.e., the flakes were stained a deep blue-green by surface adsorption, with no indications of any base-exchange capacity.

It was found possible to stain bleached biotite to some extent with both the above stains, thereby providing a useful test for distinguishing this mineral from muscovite, which generally does not adsorb any appreciable quantity of the dye. Flakes of biotite showing a marginal rim of the bleached material are common in the less severely altered portions of the granodiorite, and these, when treated with the dyes, adsorb the dye in their bleached portions, the inner area of fresh biotite remaining unstained.

(iv.) X-Ray Examination of the Clay Fraction.

X-ray "powder" photographs of the clay-fraction from the Bulla-Broadmeadows kaolin outcrops indicated that the clay-mineral is kaolinite, thus confirming the identification made by the other methods described in this section.

Procedure.—The clay-fraction, separated by sedimentation, was air-dried at 20°C., mixed into a thick paste with collodion, and extruded from a fine-bore glass tube to form a rod about 1 mm. in diameter. When dry, the rod was mounted in a circular camera, 57.3 mm. in diameter, and exposed to filtered copper radiation for four hours. Line spacings were measured on the resultant film and are necessarily approximate because of the diffuse nature of the lines. The pattern agrees fairly well with that given by Kerr (1930) for kaolinite.

Table 1.

Arc in m.m.	Intensity.	Lattice Spacings A.U.
9·9	10	4·464
10·8	10	4·194
12·4	6	3·614
13·1	5	3·424
17·9	9	2·512
19·3	10	2·344
19·5	4	2·305
22·6	4	2·005
27·6	6	1·666
31·3	7	1·487
35·8	5	1·347
38·7	4	1·233

The line corresponding to the 1.487 spacing was relatively stronger and more diffuse than the same line in the photographs of kaolinite reproduced by Ross and Kerr (1930), suggesting that a certain amount of halloysite was present in the kaolinite from Bulla. Photographs of halloysite are characterised by a strong, diffuse line (1.510 AU) which almost coincides with the kaolinite 1.487 AU line. (Ross and Kerr, 1934).

Associated Minerals.

Quartz occurs in rounded grains, showing no signs of alteration from the original form of the mineral in the fresh granodiorite. A considerable amount of fine-grained secondary quartz is present in most kaolinised specimens, especially those which were obtained from outcrops immediately below the silicified sands and gravels which cover portion of the granodiorite.

Muscovite is present in both the kaolinised granodiorite and in the fresh rock. There is only a small quantity of sericite present, most of the particles being well-developed flakes from 0.1-1 mm. across.

Bleached Biotite.—Much of the biotite of the original granodiorite has undergone extensive decomposition into a colourless material which resembles muscovite, but may be distinguished from that mineral by optical and chemical means. Thus, the bleached biotite has a smaller optic angle (2V about 10°-20°) than muscovite (2V from 30°-40°). Flakes of the bleached biotite frequently retain some of the pleochroism of the fresh mineral, whilst the completely colourless material may be readily distinguished from muscovite by its capacity for the adsorption of dyes from dilute solution. It is possible that this adsorptive effect is partly due to the presence of finely dispersed kaolinite which would probably be produced to some extent during the bleaching of the biotite.

Since little information was available regarding the composition of bleached biotite, an attempt was made to determine its probable composition by spectrographically analysing an aggregate of flakes of the mineral selected under the microscope. The spectrograms obtained, when compared with those of normal biotite, showed that the bleached material contained much less iron and magnesium, and rather less manganese, titanium and nickel than normal biotite.

Accessory Minerals.—Heavy mineral concentrates from the kaolinised material contained zircon (common), garnet (rare) and limonite (rare). Baker (1942) recorded zircon and garnet in the fresh granodiorite.

Chemical Analysis of the Kaolinised Granodiorite.

Table II. shows comparison analyses of fresh and kaolinised granodiorite from Mt. Gellibrand (Broadmeadows) and an analysis of the clay mineral (kaolinite with some halloysite), together with an analysis of the parent rock from which the clay has been derived. From columns I. and II., it can be seen that kaolinisation has been accompanied by a considerable loss of MgO, CaO, Na_2O and K_2O, the deficiency being made up by a corresponding increase in the content of chemically held water. The

amount of iron which has been removed is not great, but oxidation of ferrous iron to the ferric state has occurred to a large extent. The titanium content of the kaolinised material has increased by about 80 per cent., while most of the manganese has been

TABLE II.

	I.	II.	III.	IV.
SiO_2	67·75	67·38	66·13	45·02
Al_2O_3	16·11	16·21	16·83	35·85
Fe_2O_3	·50	3·45	1·11	·99
FeO	4·00	·48	4·17	·24
MgO	·79	·29	1·83	·65
CaO	2·68	·71	3·26	1·76
Na_2O	2·60	·86	2·25	·03
K_2O	3·42	2·35	3·14	·25
$H_2O+110°$	·20	5·72	·23	8·90
$H_2O-110°$	·96	·88	1·68	5·90
CO_2	Nil	Tr.	Tr.	Tr.
TiO_2	·85	1·40	Tr.	·57
P_2O_5	·09	·07	Tr.	Tr.
MnO	Tr.	·02	·07	Tr.
Cl	Tr.	Tr.	Tr.	Tr.
	99·95	99·82	100·70	100·16

I.—Adamellite, Mt. Gellibrand. (Analyst: H. C. Richards) (James, 1920).
II.—Kaolinised Granodiorite, Mt. Gellibrand. (Analyst: A. J. Gaskin).
III.—Granodiorite, Bulla (Analyst: F. Watson) (James, 1920).
IV.—Clay-fraction, Bulla. (Analyst: A. J. Gaskin).

removed from the altered rock. All of the above changes in composition are typical of the processes of weathering and leaching by meteoric waters, the kaolinisation of the granodiorite having rendered the granodiorite porous and particularly subject to supergene attack. The removal of such components as magnesia, lime, soda, potash, and, to some extent, iron, in the form of their soluble bicarbonates and chlorides, is to be expected in the case of an igneous rock, such as the Bulla-Broadmeadows granodiorite, which has been mechanically broken up by decomposition and exposed to atmospheric attack. The fixation of titanium in the form of the insoluble hydrated titanium oxide known as leucoxene (Edwards, 1942) is a process common in such residual products of supergene weathering as clays, bauxites and laterites. Adsorption of hydrated titanium compounds, or lattice replacement of aluminium by titanium, might account for the considerable amount of TiO_2 (0.57 per cent.), associated with the fine clay which was separated from the kaolinised granodiorite by sedimentation (Table II., Column IV.). Since there is no visible rutile or ilmenite present in the kaolinised rock, the 80 per cent. increase in its TiO_2 content must be ascribed to the presence of secondary compounds, such as leucoxene, derived from ilmenite in the original rock by the action of the solutions engaged in leaching the kaolinised masses, or from titanium-bearing solutions accompanying the extrusion of the basalts.

Spectrographic Analysis of Kaolinised Granodiorite.

Pneumatolytic action is generally accompanied by the introduction of various metallic elements into the rock body which is being attacked, though it is theoretically possible for pure water vapour, associated with mineral acids, to cause "pneumatolytic" alteration of certain minerals. It has been suggested (James, 1920), that the kaolinisation of the Bulla granodiorite was connected with the intrusion of the small tourmaline-aplite veins which occur in the granodiorite. Pneumatolytic action associated with the introduction of tourmaline is of a particularly intense nature, being commonly associated with the introduction of certain characteristic elements such as tin, tungsten, and boron. An attempt was therefore made to detect the presence of these elements in the kaolinised granodiorite, particularly in the neighbourhood of the tourmaline-aplite veins.

Spectrographic analysis was chosen as the means of determining the relative amounts of minor elements present in the fresh and kaolinised granodiorite, firstly because of the great sensitivity of the method, and secondly because of the impossibility of predicting in advance exactly which elements would show significant variations, and then applying suitable chemical spot tests. Spectrograms were taken on a Hilger "medium" quartz spectrograph, the region 2,000-4,000 AU extending the length of a 10-in. x 4-in. photographic plate. To obtain maximum sensitivity, the method of cathodic excitation in a low-voltage direct-current carbon arc (Strock, 1936) was used. Identification and intensity matching of lines were facilitated by the use of a projection densitometer, fitted with a ground glass screen and movable iron-arc and wavelength scale, constructed by the author on the lines of the projection micro-photometer described by Dietert and Schuch (1941).

Procedure.—Specimens weighing about 50 grams were selected from the various kaolinised outcrops and were treated so that representative samples, weighing no more than 20 milligrams, were obtained. In preliminary experiments, the large samples were crushed to -50 mesh, in an agate-mortar, and successively quartered until a sample weighing about 1 gram was obtained. This was crushed as finely as possible in a clean agate mortar, thoroughly mixed, and divided into minute samples for arcing. It was found necessary to burn the arc for one to two minutes at 8 amps. in order to volatilise a 20 milligram sample, which was therefore the maximum practical sample size, as complete volatilisation is necessary in an investigation which purports to compare the compositions of heterogeneous samples.

A series of spectrograms taken from samples prepared by the above method showed appreciable variations in the relative amounts of elements present, although the samples were selected

from the same "gram sample." The variations were undoubtedly due to the presence of relatively large particles of certain minerals in the samples (particularly biotite, which is extremely resistant to crushing beyond a certain grain size). Other defects of this method of sample preparation and excitation were the heavy background due to the excitation of silicon oxide molecules, and the long period of arcing necessary to volatilise the persistent globules of molten silicates which formed in the arc crater of the lower electrode, the long exposure intensifying the cyanogen band spectrum, which obliterates the fainter lines above 3380 A.U. on the spectrogram.

In order to overcome the above disadvantages, a sampling procedure was developed in which the original large rock samples were treated with hydrofluoric and sulphuric acids (5 : 1 mixture), the solutions evaporated, ignited, and leached with concentrated hydrochloric acid. The resulting solutions were evaporated to liquids of syrupy consistency, from which small samples were taken and volatilised in the arc. It was necessary to start the arc at a low current (3 amperes) and to maintain this current until the liquid in the sample had been vaporised, after which it was possible to increase the current to 10 amperes, without generating a large quantity of steam in the sample and thereby blowing it from the crater. In this method, the elements are vaporised in the form of their chlorides, which produce clearer and more intense spectra, completely free from the silicon oxide band spectrum. The relative volatility of the chlorides results in the complete volatilisation of the sample within a one-minute arcing period. Successive spectrograms taken by this method showed a high degree of consistency, coupled with a greater sensitivity than had been obtained by arcing the powdered minerals alone.

Spectrograms were taken with a Hoffmann diaphragm fitted over the spectrograph slit, so that three successive spectrograms could be photographed on any section of the plate. The uppermost of the series was always made an iron arc comparison spectrum indispensable in calculating the wavelength of the lines in the lower spectrograms, which were taken from kaolinised and normal granodiorite, respectively. In no instance did lines of any trace element consistently appear in the spectrograms of the kaolinised material, without appearing to the same (or greater) extent in the fresh granodiorite. Among the trace elements appearing in the spectro-analyses were boron, zirconium, nickel, and vanadium. The relative amounts of the major elements in the fresh and kaolinised granodiorite, as shown in the spectrograms, corresponded with the values shown in the chemical analysis (Table II.).

The Origin of the Kaolinisation.

Mineralogical Evidence.

There are certain facts in the mineralogical data presented above which have a bearing on the problem of the origin of the kaolinised deposits. These facts are concerned with the type of clay mineral, the nature of the associated alteration products, and the presence or absence of pneumatolytic elements in the deposits.

(1) The clay mineral in all the kaolinised portions of the area has been shown (above) to be kaolinite, the clay mineral characteristic of low-temperature kaolinisation (Ross and Kerr, 1930). Dickite and nacrite, the kaolin minerals formed under hydrothermal and pneumatolytic conditions, respectively, are absent from the Bulla-Broadmeadows deposits, indicating that the temperature of kaolinisation was not high, probably not above 100°C. The fact that kaolinisation has taken place is in itself an indication of the presence of acids or acid gases at the time of alteration. The kaolinising action of carbonic acid has been demonstrated by Parsons (1923), that of hydrochloric acid by Schwarz and Trageser (1933), and by Gruner (1939), and that of sulphuric acid by Anderson (1935). Although much hydrofluoric acid would probably have been present if the alteration were pneumatolytic, Gruner (*loc. cit.*) has shown that this acid has apparently no kaolinising action. It is generally reported that lignic acids produced in swamp deposits have a definite kaolinising action on granitic rocks, even at normal atmospheric temperatures.

(2) From a comparison of the mineralogical features of the fresh and kaolinised granodiorite, it can be deduced that the changes that have taken place during alteration are:—kaolinisation of all felspar and some of the biotite and sericite, bleaching of most of the biotite, and production of some secondary muscovite.

Bleaching of biotite appears to be a weathering process involving the action of acids, as a similar bleaching effect can be produced by digesting the fresh mineral in hot dilute hydrochloric acid. The usual chloritic products of the atmospheric weathering of biotite are common in the solid granodiorite at Bulla and Broadmeadows, but do not occur in the kaolinised portions of the intrusion. Further evidence regarding the low-temperature nature of the alteration is provided by the absence of large quantities of muscovite or sericite from the kaolinised material. Gruner (*loc. cit.*) has shown that, in the presence of potash, kaolinite reverts to sericite at temperatures above about 400°C., so that this figure could be set as the probable upper limit of the kaolinisation temperature in this instance.

(3) The absence of pneumatolytic elements from the kaolinised granodiorite has been demonstrated (above) by comparing spectrographic analyses of the kaolinised material with those of

the fresh rock. The result supports the mineralogical evidence regarding the absence of pneumatolytic minerals from the kaolinised granodiorite. However, a serious limitation of the spectrographic method is the impossibility of detecting the presence of the negative radicals which would probably be introduced during the kaolinisation. The application of chemical tests to the kaolinised material showed that small quantities of the carbonate and chloride radicals were present but that the sulphate radical was not present in detectable amounts. Since the radicals detected are normally present in traces in all rocks exposed to atmospheric attack, their presence in this instance is of no significance in the determination of the cause of kaolinisation. A simple comparison between the relative amounts of such radicals in the fresh and in the altered rock is not possible because of their great difference in physical character. The high porosity and adsorptive capacity of the kaolinised material would naturally result in a higher concentration in it of carbonic acid and sodium chloride derived from the atmosphere, whilst the porosity of the material would permit of the ready escape of any concentration of a soluble salt or acid introduced during pneumatolysis.

Zircon is present in equal amounts in both fresh and kaolinised granodiorite, and shows no significant alteration effects. Comparison of heavy mineral concentrates prepared from fresh and kaolinised material indicated that no "pneumatolytic" minerals such as tourmaline or topaz had been introduced during kaolinisation.

The evidence provided by the minerals associated with the kaolinite is thus in agreement with the evidence in (1) above, i.e., leading to the conclusion that kaolinisation took place in an acidic environment at a temperature between 0°C. and 400°C., in the absence of any appreciable quantities of foreign metallic elements. Such conditions could have been brought about by the action of:

(*a*) Acidic liquids or gases associated with the final cooling phases of the solid granodiorite, the composition of the kaolinising agency being limited to a relatively pure acidic material containing few or none of the elements usually associated with pneumatolytic or hydrothermal attack. No mineralogical evidence could be found to support the idea that kaolinisation was due to "pneumatolysis" in the accepted sense of that term. However, the nature of the altered material is rather more compatible with the milder "hydrothermal" attack.

(*b*) Acidic liquids produced in swamp deposits on the granodiorite surface, prior to the extrusion of the Tertiary basalts.

(*c*) Acidic liquids or gases associated with the extrusion of the overlying basalts, either included in gaseous form in the flows themselves, or dissolved in the meteoric waters accompanying the eruption.

Since any one of the above agencies could have produced the mineralogical and chemical features of the deposits, the field evidence must be relied upon to decide which is the most probable hypothesis.

Field Evidence.

Kaolinisation of the granodiorite subsequent to, or immediately preceding, the extrusion of the Tertiary basalts would have had little or no influence on the physiographic development of the area, because of the protective covering afforded by the extrusives. The fact that the kaolinisation has had no apparent influence on the physiographic development of the area in either pre-basaltic or post-basaltic time is thus strong evidence in favour of the idea that kaolinisation did not take place before the development of the land surface on which the basalts were extruded. This evidence thus opposes the "pneumatolytic" theory. There are numerous indications that the kaolinised areas have had no apparent influence on the form of the pre-basaltic land surface. Among them is the fact that within a distance of a few hundred yards, there is a difference of over a hundred feet in the elevations of the upper surface of the main kaolinised outcrop at Broadmeadows, and the upper surface of the deposit lying to the south (see Section I.). It is a significant fact that the surface of the lower outcrop shows a particularly cleancut junction with the overlying basalt, and does not exhibit the disturbed and re-distributed appearance of a valley floor cut in kaolinised material.

If kaolinisation had long preceded the extrusion of the basalt, sedimentary clay deposits representing re-distributed kaolinised granodiorite would probably have been formed. No such sediments are known, the nearest clay deposits (at Campbellfield) being post-basaltic.

With regard to the angular boulders of kaolinised material at Bulla, it seems probable that the kaolinised granodiorite was too friable to have retained such shapes, which are, however, characteristic of boulders of fresh granodiorite. This suggests that the kaolinisation of the boulders in the grit took place after the deposition of the grit, presumably by some agency associated with the extrusion of the overlying basalt. A search among boulders in the grits and sands above some of the kaolin outcrops failed to reveal any fresh unaltered granodiorite.

It has been suggested (James, 1920) that the shape of the kaolinised masses at Bulla is that which is characteristic of kaolin deposits produced by pneumatolysis, but in no case was it found possible to substantiate this statement in the field, as the boundaries of the kaolinised masses are not exposed to any extent in the quarries and gullies. All that can be established with certainty is the fact that the kaolinised masses do not increase rapidly in extent with increase in depth, a point which can be deduced

from the occurrences of fresh granodiorite below and at the sides of kaolinised outcrops (K.3), (K.4) and (K.5).

The presence of tourmaline veins in the kaolin quarries on the east bank of Deep Creek has been quoted by James (1920), as positive evidence of pneumatolysis in connection with the kaolinisation. One vein occurs in each quarry, and a similar vein, passing through practically unaltered granodiorite, is now exposed in the floor of the gully on the western side of Deep Creek. All of the veins have a maximum thickness of about 1 inch, and show sharp boundaries with the surrounding rock. In structure, the veins resemble fine-grained pegmatites, as they contain relatively large crystals of tourmaline, quartz and fresh felspar. The presence of the fresh felspar could be explained, if kaolinisation were due to the action of acidic liquids percolating down from above, by assuming that the compact nature of the veins protected the felspar. If it is assumed that the veins acted as feed channels for the kaolinising agencies, as they would have done if kaolinisation were due to pneumatolysis associated with their intrusion, it becomes difficult to account for the fact that the felspar which they contain is not even partially altered.

A suggestive point in the evidence is the fact that nowhere in the area does the kaolinised material occur above the level of the basalt surface, although in several places the upper limit of kaolinisation is almost on the same level as the surface of the basalt. There are no kaolinised exposures in those portions of the granodiorite which have been removed from contact with either the basalt itself, or solutions accompanying the basalt.

At Broadmeadows, no evidence could be found to support the suggestion that kaolinisation was in any way connected with the intrusion of the dyke-like body. There is no quantity of tourmaline or any other mineral associated with pneumatolysis in it or in any part of the quarry, and there are no signs of disturbance along the contacts of the dyke with the surrounding granodiorite such as would be expected if the dyke had acted as the plane of weakness along which the kaolinising agencies had moved. No variation in the degree of kaolinisation of the surrounding granodiorite could be found within the limits of the excavation, which extends at least 70 feet in either direction at right angles to the strike of the dyke.

Discussion.

The three possible modes of origin suggested by the mineralogical evidence may now be reviewed in the light of the above field evidence.

(*a*) Kaolinising agencies associated with the intrusion of the granodiorite would have to have been of an unusual type to comply with the mineralogical evidence discussed above. The only obvious way in which lime, magnesia, and alkalies could have been completely removed from the fresh rock, would seem to be

the contact of percolating waters with the solid granodiorite in the final cooling stage of the intrusion. It is becoming increasingly evident that there are very few definite instances of kaolinisation by agencies associated with the parent intrusions, there is even reason to doubt the evidence at Cornwall (Collins, 1909), which has long been cited as the classic example of "pneumatolytic" kaolinisation (Ross and Kerr, 1930). In the present case, the absence of minerals and trace elements typical of pneumatolytic and hydrothermal action, the nature of the clay minerals formed during the alteration, and the various points quoted in the field evidence (above) are considerable obstacles to the development of the theory.

(*b*) Kaolinisation due to the action of natural waters containing organic acids derived from decomposing vegetation in swamps is a recognised process (Kerr, 1930), and one which could have given rise to the mineralogical and chemical associations of the Bulla-Broadmeadows deposits. Field evidence, however, opposes the hypothesis, since it opposes the idea of pre-basaltic kaolinisation. The only favourable evidence available is the fact that James (1920) has shown that lacustrine deposits containing plant remains, occur between the Silurian bedrock and the overlying basalts in parts of the Bulla district. It is not improbable that similar deposits formerly occurred in depressions in the surface of the granodiorite and gave rise to acidic solutions which penetrated and kaolinised the underlying granodiorite during the period immediately prior to the extrusion of the basalts. Pre-basaltic erosion might account for the absence of the sediments from the neighbourhood of most of the kaolinised masses at present exposed.

(*c*) Although there is no conclusive evidence for the hypothesis that assigns the kaolinisation to the effect of acidic liquors associated with the extrusion of the basalts, the theory suffices to explain the mineralogical and chemical characteristics of the kaolinised masses, and is in accord with the available field evidence. There is no evidence in opposition to the idea, the only point raised by James (1920) being the fact that fresh granodiorite underlies the basalt in two places. This evidence seems rather to be directed against the idea that kaolinisation was brought about by the direct heating action of the molten basalt, a factor which it is certain would have played little or no part in the kaolinisation, because of the low thermal conductivity of the granodiorite, especially if dry. A more probable mechanism is that in which acid vapours, evolved during the extrusion of the basalts, dissolved in the magmatic and meteoric waters accompanying the event, and formed acidic solutions. The latter trapped up against the edges of the lower-lying basalt flows, from there penetrated beneath the basalts and caused the kaolinisation of the under-lying granodiorite. Such alteration would be

localised in limited areas, the location of which would be determined by a number of independent variables, such as relative altitude, permeability, temperature of the flows and solutions, and the various drainage factors which would control the collection and distribution of the active liquids

Conclusion.

Summary.

The conditions under which kaolinisation took place can now be postulated with some certainty, but there is insufficient positive evidence available to permit of a definite decision being made in favour of any one of the three probable modes of origin. Although there is no conclusive evidence to discount the possibility of kaolinisation being due to agencies associated with the intrusion of the granodiorite, or to solutions produced in overlying swamp deposits, the evidence in favour of these theories is not as convincing as that which supports the view that the kaolinisation was connected with the evolution of acidic liquors and gases accompanying the extrusion of the Tertiary basalts.

Acknowledgments.

I would like to express my appreciation of the assistance and encouragement given during this investigation by Professor Summers and the staff of the Geology School at Melbourne University. My thanks are also due to Dr. Anderson for instruction in spectrographic analysis; to Professor Hartung for permission to use the spectrograph in the Chemistry Department; to Dr. Boas for his assistance in obtaining X-ray data; and to Professor Greenwood for permission to use equipment in the Metallurgy School.

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Art. II.—*Contact Phenomena in the Morang Hills, Victoria.*

By A. B. EDWARDS, D.Sc., and G. BAKER, M.Sc.

[Read 10th June, 1943; issued separately 1st August, 1944.]

Abstract.

The Morang Hills are 20 miles N.N.E. of Melbourne, and consist of a small inlier of Silurian sediments and Devonian granodiorite in an area of Tertiary Newer Volcanic basalt flows. The sediments are predominantly mudstones and shales and form a thin cover above the granodiorite. They show progressive metamorphism through spotted muscovite hornfels, and biotite-hornfels to relatively coarse-grained cordierite-biotite-hornfels as the granitic contact is approached. The north-eastern part of the contact is occupied by a sillimanite-andalusite-hornfels, rich in orthoclase.

Along its margin, and particularly at its contact with the sillimanite-andalusite hornfels, the granodiorite, which is otherwise normal, passes into a potash-rich phase, studded with giant phenocrysts of orthoclase. The extra potash appears to be derived from assimilation of the potash-rich contact rocks at a time when the magma had come to rest, and lost much of its original fluidity.

Introduction.

The Morang Hills are situated about 20 miles N.N.E. of Melbourne, and 3 miles N.E. of Epping. The railway line to Whittlesea turns eastward between Epping and South Morang in order to by-pass them (fig. 1). The hills rise to a height of 850 feet above sea-level, and consist of Silurian sediments, intruded and thermally metamorphosed by a small stock of (?) Devonian granodiorite. The metamorphic zone extends for a quarter to half a mile from the granodiorite contact (fig. 2), and the marginal granodiorite is characterised by giant phenocrysts of orthoclase, which occur only sparsely in the interior of the stock.

The Palaeozoic rocks form an inlier 4 miles long (N.-S.) by 3 miles broad, in an area of Newer Volcanic basalt flows, and rise about 300 feet above the surrounding plain, the surface of which is broken by small "stony rises." The basalt flows came from the north, obliterating the pre-existing streams.

The Morang Hills have the form of two north-south ridges separated by a south-trending valley a quarter to half a mile wide, and 250 to 300 feet deep. The western, or Quarry Hill, ridge is 100 to 150 feet higher than the eastern ridge, and consists of hard, dense hornfels, forming a cover about 200 feet thick over the granodiorite, which is exposed in a quarry on the south-eastern side of the ridge (fig. 2). The eastern ridge consists of granodiorite, fringed by less resistant metamorphosed sediments. The short and intermittent creeks draining the hills have

built alluvial flats where they debouch on to the basalt plains. The main streams of the area are the Darebin Creek, on the west, and the Plenty River on the east. The Darebin Creek, over part of its course, follows the boundary of the Silurian sediments with the basalt.

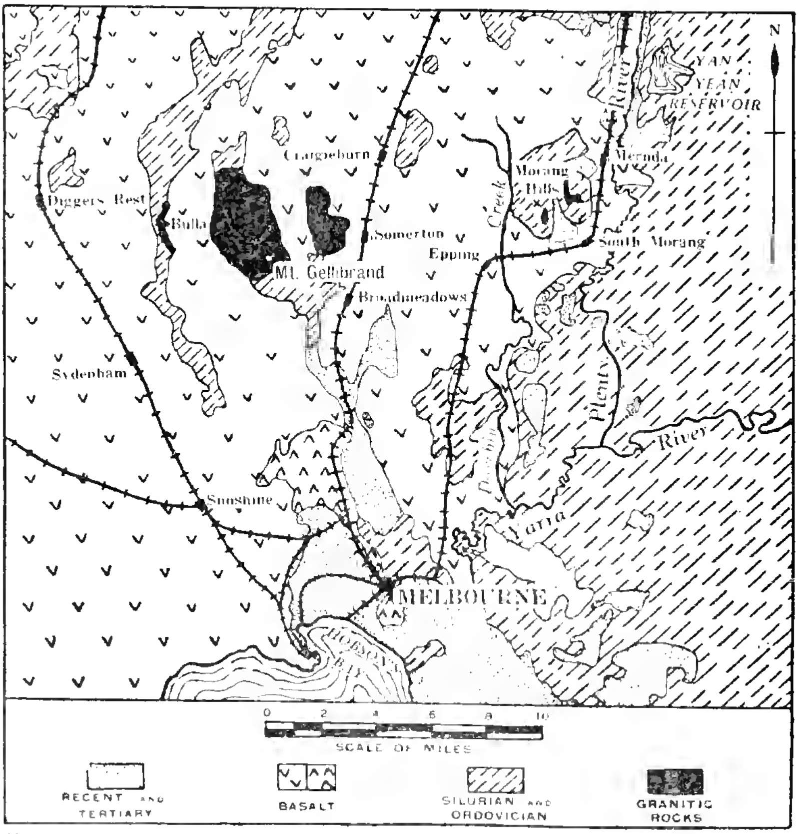

FIG. 1.—Locality Map showing the position of the Quarry Hill Area and Neighbouring Granite Rocks outcropping at Bulla and Mt. Gellibrand. Drawn, with modifications, from the Geological Map of South Central Victoria (Handbook for Victoria, 1935).

The area was first geologically surveyed by Etheridge in 1868, in connection with the preparation of Quarter Sheet No. 2 N.E. Jutson (1910) referred to it briefly in his study of the Plenty River, and a brief note on the Morang granodiorite has been published by Howitt (1936). Kenny (1937) reported upon the gold-bearing alluvial lead at South Morang, and Skeats and James (1937) compared the stony rises of the basalt plains with those of the Colac District.

Interest in the area attached chiefly to the metamorphic changes induced in the Silurian sediments, and to the hybrid origin of the margin of the intrusion.

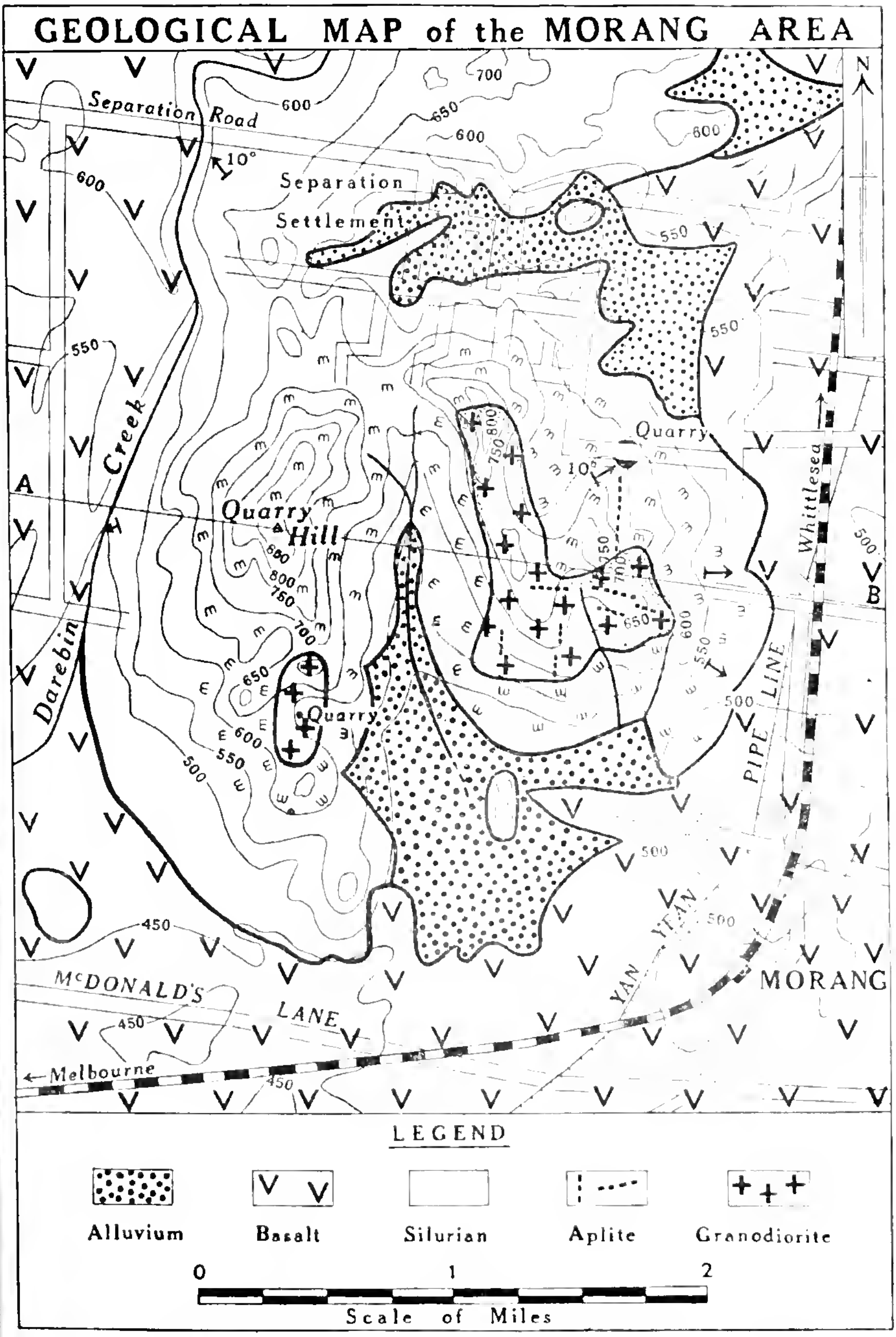

FIG. 2.—Geological Map of the Morang Area, based on Military Survey Sheet of Yan Yean and Quarter Sheet No. 2 N.E. of the Victorian Geological Survey.

The Silurian Sediments.

The Silurian sediments consist of finely-bedded mudstones and shales, with an occasional interbedded sandstone band. Their geological relationships are largely masked by soil and hillwash, but such dips as could be found indicate that they occur in a dome-like structure with outward dips of from 10°-20° (fig. 2). The best exposures are in the Country Roads Board quarry, to the north-east of the eastern outcrop of granodiorite, and on Separation-road near the bridge over Darebin Creek. No fossils have been found in the Morang Hills, but there can be little doubt that they represent a continuation of lithologically similar, fossiliferous rocks of Silurian age which outcrop a few miles to the north (Jutson, 1908).

Contact Metamorphism.

Mudstones and Shales.

The successive stages in the metamorphism of the original argillaceous shales and mudstones are best seen between Darebin Creek and the western granodiorite outcrop. The unaltered sediments are fine-grained rocks consisting of varying proportions of quartz, chlorite, and sericitic material, with lesser amounts of accessory iron ores, and detrital zircon, rutile and sphene. In the outer aureole, the first signs of metamorphic change are induration of the sediments and the appearance of small wisps of secondary mica. With increased recrystallization, the amount of secondary mica formed increases, and the mica tends to segregate, so that the rocks appear spotted. The spots are rich in pale-green and white mica, and are spherical to ovoid in shape. They have ill-defined boundaries, and merge into the surrounding matrix. Closer to the contact, but still at about 300 yards or more from it, the spotted texture becomes pronounced, owing to the increased size of the secondary mica plates. In places the spots consist largely of limonite, formed from the weathering of iron ores associated with the segregated mica plates. Generally, however, and particularly in the more arenaceous rocks, they are made up chiefly of clear white or pale yellowish-green mica, and are separated by interstitial areas rich in quartz. According to Tilley (1924, p. 28), such spots in the contact rocks of an outer aureole are due to the selective aggregation of directional minerals under the influence of interstitial solutions, derived in part from the sediment and possibly in part from the magma.

Zone of Biotite Development.

Closer to the contact, but in some parts of the aureole at distances of almost 300 yards from it, biotite begins to make its appearance as small plates, some of which are bleb-like and are included in quartz crystals. The quartz grains of the sediments have grown larger, and the white mica now forms laths and plates

of muscovite. The appearance of biotite marks a significant change in the nature of the metamorphism, from one involving only recrystallization of existing minerals, to one involving chemical reconstruction of the rock, and the formation of new minerals (Tilley, 1924, p. 29). The biotite is formed from chemical reactions involving the chlorite, sericitic material, iron oxides, rutile and silica of the mudstones and shales, which now lose much of their residual structures, and pass into more or less spotted hornfels. At this stage, the titanium minerals in the sediments have recrystallized to form numerous minute and scattered crystals of rutile, with sporadic crystals of brookite, and rare anatase. The detrital sphene has recrystallized to form clusters and strings of granular sphene, and occasional small prisms of tourmaline make their appearance. These indicate slight pneumatolysis. The iron ores and zircons remain unchanged.

Zone of Cordierite Development.

Still closer to the contact cordierite makes its appearance. The zone of cordierite development is usually from 200 to 250 yards from the contact, and in one place is a quarter of a mile from an observed contact. This exceptional occurrence is found at Country Roads Board quarry, and suggests that the granodiorite is close to the surface at this locality.

The rocks are still spotted in this zone of the aureole, but the spots now consist of poikiloblastic cordierite crystals, which are replacing the original micaceous spots. The cordierite crystals have irregular outlines, and show sixfold twinning. They contain innumerable inclusions, consisting of iron-ore dust, minute flakes of biotite and plates of muscovite. The inclusions are often confined to the centres of the cordierite crystals, the margins of the crystals being clear. The matrix of the rock consists of numerous laths and small plates of biotite and granular crystals of quartz, together with abundant minute crystals of rutile, lesser brookite and sphene, and some waterworn zircons. The rocks may be classed as cordierite-biotite hornfels, with fine-grained granoblastic texture. The biotite, though still present only as minute crystals, has passed the bleb stage. The abundance of cordierite, and the absence of andalusite from this zone is probably due to the high chlorite content of the original sediments (Tilley, 1924, p. 31). Where rocks in this zone were originally rich in sericitic material, they have formed sericite-biotite-quartz hornfels, comparable with those developed at Bulla (Tattam, 1925, p. 233), and lacking in cordierite.

With more intense metamorphism, the cordierite hornfels and biotite-quartz hornfels become somewhat coarser-grained, and their iron ore grains become fringed with biotite as they approach the actual contact; but no additional new minerals make their appearance, other than occasional grains of diopside.

Sillimanite-Andalusite Rocks.

Along the northern contact of the bulge on the eastern side of the more easterly granodiorite outcrop, varieties of thermally altered rocks occur which have not been observed elsewhere in the aureole. They appear to have been formed from argillaceous sediments which were rich in sericite, but much poorer in chlorite than the sediments which gave rise to the cordierite hornfels or the biotite-quartz hornfels. Most conspicuous among them is a porphyroblastic rock, in which the spots, which are up to 5 mm. across, consist of felted masses of sillimanite fibres, accompanied by plates of colourless muscovite and occasional flakes of biotite. Within the spots are found occasional frayed and embayed crystals of andalusite. These inclusions, in conjunction with the commonly idioblastic form of the spots, indicates that the spots once consisted entirely of andalusite, and that with progressive metamorphism the andalusite has been largely converted into sillimanite. Orthoclase is present as numerous granular crystals and xenoblasts in the matrix. Tilley (1924, p. 60) has shown that orthoclase can be formed from interaction of sericite and silica (quartz), with the production of andalusite as a by-product, or by the reaction of biotite with quartz. The latter reaction, however, involves the simultaneous formation of cordierite, and since no cordierite has been found in the sillimanite-andalusite rocks at Morang, it is thought that the orthoclase and the original andalusite developed from original sericite. Any soda in the sericite has formed occasional crystals of oligoclase, or has entered into solid solution in the orthoclase. The orthoclase and oligoclase occasionally occur intergrown in diablastic structures.

The alkali content of the rock is K_2O 5·19, Na_2O 1·99. The potash content is high, but not unduly high for mudstones, as compared with other analysed Palaeozoic mudstones and slates from Victoria (Howitt, 1923). The soda content, however, is unusually high for a mudstone so rich in potash, so that some proportion of the alkalis may have been introduced from the granodiorite. If this occurred, it is likely that soda rather than potash was introduced, since, as shown later, the granodiorite magma appears to have been saturated with soda, but undersaturated with respect to potash.

Brown and reddish-brown biotite, quartz, and, occasionally, tourmaline, are the other chief constituents of the sillimanite-andalusite hornfels. The biotite has been partially altered to pale-coloured chlorite, with the precipitation of rutile as long needles and as sagenitic webs. The accessory minerals present are waterworn zircons, with occasional rutile, brookite and sphene crystals, and in some specimens, abundant iron ores.

Associated with this distinctive spotted hornfels are arenaceous and muscovite hornfelses, of variable grain size, which characteristically contain abundant limonite, derived from the fine-grained iron ores of the original rock. They are soft, crumbly rocks, which are much more readily eroded than the dense, quartz-biotite hornfels and cordierite hornfels of the Quarry Hill ridge.

Arenaceous Sediments.

Arenaceous sediments, though present in the Morang aureole, are of such restricted occurrence that it is impossible to trace the successive stages of their metamorphism. In general, the hornfelses derived from them resemble those derived from the more sandy argillaceous rocks, but contain more quartz. Some approach quartzites in composition and consist of a mosaic of interlocking quartz crystals, with occasional interstitial areas of greyish-brown, crypto-crystalline material which appears to be a mixture of sericite and chlorite. Others, originally richer in chlorite and sericite, contain wisps and plates of muscovite, and of pale-green and pale-brown mica. A feature of the arenaceous hornfelses is that they almost completely lack the grains of iron ore that are so abundant in many of the altered argillaceous rocks. Rutile, brookite, and sphene are similarly lacking, though occasionally detrital crystals of these minerals are found associated with well-defined strings of waterworn zircon crystals lying along an original bedding plane. Another difference from the argillaceous hornfelses is the small number of spotted structures in the arenaceous hornfels. When spots are present, they consist of clots of muscovite plates.

Along the eastern ridge, scattered boulders of brecciated, fine-grained, arenaceous hornfels have been found both north and south of the eastern bulge in the granodiorite outcrop. The angular fragments of hornfels, together with occasional fragments of quartz are cemented together by limonite, and some of the hornfels fragments are traversed by small quartz veins. The presence of the small quartz veins suggests that the brecciation occurred in the interval between metamorphism and the late stages of consolidation of the granodiorite.

Grain Size.

The hornfelses generally show an increase in grain size as the granodiorite junction is approached. Thus, in a micaceous variety, 300 yards from the contact, the quartz grains average about 0·04 mm. across; in a spotted hornfels, 200 yards from the contact, they are 0·08 mm. across; in an arenaceous hornfels, 100 yards from the contact, they are 0·1 mm. across; while in the sillimanite-andalusite hornfels at the contact the average size of the quartz grains is between 0·4 and 0·8 mm. across. For com-

parison, it may be noted that quartz crystals in the granodiorite average 2·5 mm. in diameter, and are up to 4 mm. across in the porphyritic marginal granodiorite, while in the xenoliths they range between 0·8 and 1·5 mm. across. The rocks close to the granodiorite are not invariably coarse-grained, however. Some are little coarser-grained than the sediments from which they are derived, and according to Tilley (1924, p. 64) neither differences in original grain size nor differences in composition can account for these grain size anomalies.

LAMINATED HORNFELS.

The increase in grain size with more intense metamorphism arises from an increased range of diffusion, and this leads to a corresponding destruction of residual or palimpsest structures. Where the original sediments were finely bedded or current-bedded, with alternating beds of variable composition, the hornfels derived from them show a corresponding lamination, bands of arenaceous hornfels alternating with bands of argillaceous hornfels. There may be as many as 30 such laminae to the inch, and in some of the laminae lamellar minerals like biotite and muscovite are arranged in sub-parallel fashion. This type of structure persists into the zone of cordierite development, but close to the contact the complete recrystallization and reconstitution of the rocks has generally destroyed all traces of it. It is best seen in weathered hornfels in the Country Roads Board quarry (fig. 3) and on Quarry Hill (fig. 4).

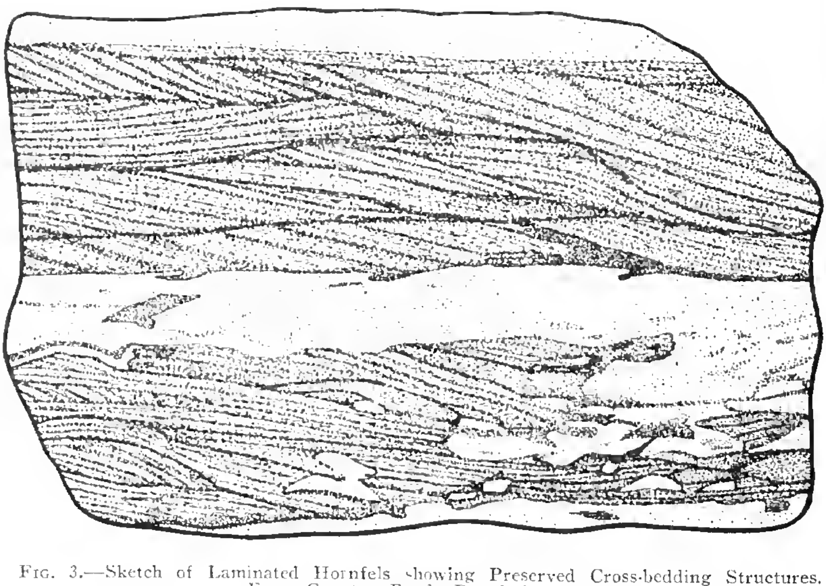

FIG. 3.—Sketch of Laminated Hornfels showing Preserved Cross-bedding Structures. From Country Roads Board Quarry.

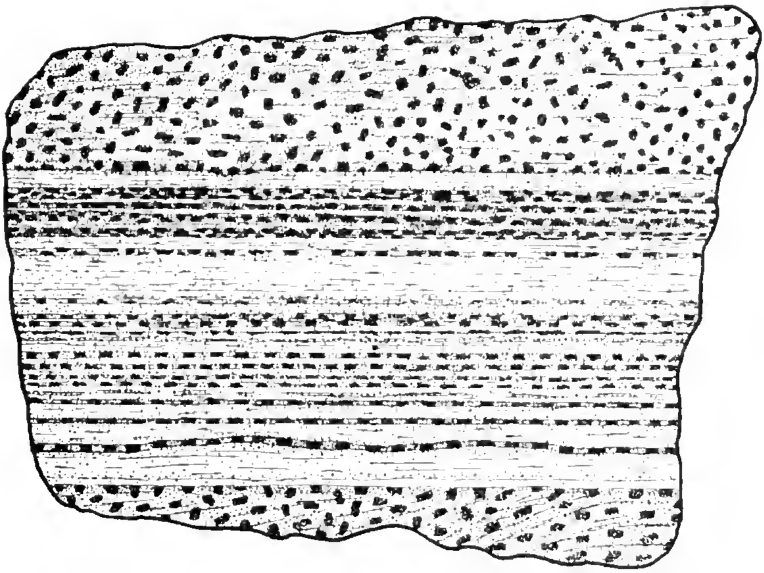

Fig. 4.—Sketch of Banded Hornfels from Quarry Hill, showing Bedding Structures preserved by narrow alternating bands of Spotted Hornfels and Arenaceous Hornfels.

Remarks on the Contact Metamorphic Zones.

The contact aureole at Morang resembles in many respects that at Bulla (James, 1920; Tattam, 1925), but there are some points of difference. The temperature of the Morang intrusion was not very high, since hydrated minerals are present in the contact rocks, and persist right up to the granodiorite junctions. The contact rocks at Morang, moreover, are all free-silica, non-calcic hornfels, and the characteristic rocks of the aureole are argillaceous types. As a result, spinellids are absent, and corundum is rare. Corundum, armoured about with mica, has been observed in only one section. The biotite "beards" fringing the ilmenite grains indicate that this mineral contributed to the formation of biotite, much as in some igneous rocks. Small amounts of lime in the original sediments have recrystallized to form a few minute grains of pale-green diopside and occasional crystals of oligoclase. The original detrital sphene in the partially metamorphosed sediments recrystallized to form sphene granules in the more intensely altered rocks; and the abundant apatite in the hornfelses is largely derived in the same way from detrital apatite, but some phosphorus seems to have been introduced from the magma, since close to the contact the apatite occasionally occurs in small veinlets. Tourmaline is only sparsely developed, and topaz is doubtfully present in small amount, showing that the inner contact rocks have been subjected to only slight pneumatolysis.

Xenoliths in the Granodiorite.

Xenoliths derived from the sedimentary rocks are relatively numerous in the more easterly exposure of granodiorite, but not in its porphyritic margin, despite the prevalence of xenocrysts and products of assimilation in this zone. The xenoliths range in size from less than an inch up to 18 inches in diameter. They show various stages of granitisation (Baker, 1936), and are sometimes foliated, the foliation resulting from an initial variation in composition of alternating lamellae such as gave rise to the laminated hornfelses.

In the early stages of reconstitution, the xenoliths consist of granular rocks not very different from the hornfels close to the contact. In some instances, the invasion of material from the granodiorite magma has caused the formation of phenocrysts of oligoclase and poikiliths of orthoclase and quartz. With advancing reconstitution, coarser-grained patches develop in the originally fine-grained xenoliths, and these coarse-grained areas spread until the whole xenolith has a granitic texture. The porphyritic intermediate stages of the transition commonly resemble biotite-rhyodacites, both in texture and in mineral composition.

The completely reconstituted xenoliths can be divided into three groups according to their mineral composition:—

(1) orthoclase-biotite-quartz rocks, with little or no plagioclase;

(2) oligoclase-biotite-quartz rocks, with little or no orthoclase; and

(3) oligoclase-hornblende-biotite-quartz rocks, in which there is little or no orthoclase.

The xenoliths of group 1 represent potash-rich contact rocks which have been further recrystallized, without marked metasomatic alteration. Those of group 2 appear to have been derived from similar rocks, but have undergone metasomatic changes, soda and lime from the granodiorite magma having been substituted for the potash of the original hornfels. In the group 3 xenoliths, metasomatic alteration has gone further, and the biotite has also been affected. In the least reconstituted rocks, the biotite first appeared as small blebs, which with increasing granitisation, grew first into small laths, which collected into decussate patches, and then "coalesced" or were "welded" into large plates. Finally, the biotite commenced to react with the lime brought in by the invading magmatic solutions, and changed over to hornblende. At the same time, the titanium in the biotite was thrown down as sphene. The hornblende formed by the reaction grew into large plates showing sieve structure, and enclosing remnants of the original biotite, and the precipitated

sphene crystals. The K_2O of the biotite presumably passed into the granodiorite magma along with the K_2O from the original orthoclase.

Where clots of ferromagnesian minerals came into direct contact with the granodiorite magma, they tended to react with it and form pink almandine garnets (Edwards, 1936). Zircon is the only mineral in the original sediments which resisted recrystallization, and well-rounded, waterworn zircons are found in each class of xenolith. In the completely reconstituted xenoliths, however, idiomorphic zircons surrounded by pleochroic haloes are also present, as inclusions in both the hornblende and the biotite, and such zircons were presumably introduced from the granodiorite magma. A common feature of all the xenoliths is the abundance of rods and needles of apatite, which are included in later-formed minerals, and represent recrystallized lime phosphate from the original sediments. A second generation of apatite crystals, appearing in some xenoliths in the form of much larger crystals represents lime phosphate introduced from magmatic solutions soaking through the xenoliths.

Granodiorite.

The granodiorite is a mesocratic, medium to fine-grained rock, with occasional phenocrysts of orthoclase up to ½-inch across. It consists of allotriomorphic and interstitial quartz grains, zoned and twinned oligoclase showing partial alteration to sericite, partly kaolinised orthoclase, biotite, and occasionally hornblende. The hornblende is derived from the assimilation of xenoliths, in which it was formed during their chemical reconstitution by a substitution of lime from the magma for the potash of original biotite. The biotite is occasionally chloritised, and associated with calcite. It carries inclusions of zircon surrounded by intense pleochroic haloes, and of ilmenite and small apatite crystals. The apatite also occurs as large individual crystals not enclosed in biotite. The biotite also contains inclusions of a pale yellowish-green weakly pleochroic micaceous mineral, which is surrounded by pronounced pleochroic haloes 0.02 mm. wide. The individual inclusions are too small for precise determination, but the mineral appears to be one of the radioactive, light-coloured micas (Johannsen, 1914, p. 323). It has a maximum absorption in the same direction as the biotite, but has a lower refractive index. Its birefringence is high, and it shows anomalous extinction. Orthite is present occasionally (Baker, 1937, p. 56, fig. 8). Small amounts of pyrrhotite and molybdenite occur in joint planes in the quarry on the western ridge.

The heavy minerals are listed in Table 1, where they are compared with the heavy minerals of the neighbouring granitic rocks of Mount Gellibrand and Bulla. The heavy mineral suites of the

three rocks are closely comparable, particularly with respect to the essential heavy minerals, and the primary accessory minerals. The separation of the heavy minerals was carried out in bromoform of specific gravity 2.88, in the manner described by Baker (1942, p. 201).

A chemical analysis of the rock (Table 2, No. 2) shows that it is a typical granodiorite, and that it closely resembles in composition the granodiorites of Bulla and Mount Gellibrand (Table 2, Nos. 3 and 4).

Jointing in the granite is not conspicuous. The most prominent planes are vertical and strike N.W.-S.E. Subsidiary joints strike E.-W. and N.10°E. Tors formed on weathering are small, rarely exceeding 10 feet in height.

Table 1.—Showing heavy mineral index numbers and assemblages of three related granodioritic rocks in South-Central Victoria.

—	South Morang (West Outcrop).	Bulla.	Mt. Gellibrand, Broadmeadows.
Index Number	11·68	10·71	9·42
Actinolite	..	..	V
Apatite (colourless)	a	a	a
Apatite (pale yellowish-green)	V	o	r
Biotite	a	A	A
Brookite	X	V	..
Chlorite	o	A	o
Corundum	V	..	..
Epidote	X	..	r
Garnet	o	o	V
Gold	..	..	V
Hematite	r	..	..
Hornblende	o	..	..
Ilmenite	o	r	o
Magnetite	..	..	V
Orthite	X	..	..
Rutile	X	..	o
Sulphides	o	r	o
Tourmaline	V	..	V
White Mica	C	C	o
Zircon (colourless)	C	C	C
Zircon (pale yellow)	V	V	C
Zircon (inclusions in)	C	r	o

Key.—A—very abundant; a—abudant; C—common; o—occasional; r—rare; V—very rare; X—recorded from thin sections.

The heavy mineral assemblages of neighbouring granodiorites in South-Central Victoria (Table 1) were obtained from the separation of crushed, fresh, representative rock in bromoform of specific gravity 2.88 and their index numbers obtained in the manner described elsewhere (Baker, 1942, p. 201). The brookite noted in the Bulla granodiorite is recorded from one grain only of that mineral, while minerals marked X in Table 1 only appeared in thin sections of rocks from certain portions of the outcrops.

TABLE 2.—Showing chemical analyses of neighbouring granodioritic rocks in South-Central Victoria.

—	I.	II.	III.	IV.	V.
SiO_2	66·30	69·17	66·13	67·75	..
Al_2O_3	16·42	15·95	16·83	16·11	..
Fe_2O_3	0·52	0·88	1·11	0·50	..
FeO	3·00	3·64	4·17	4·00	..
MgO	1·05	1·12	1·83	0·79	..
CaO	1·85	3·04	3·26	2·68	..
Na_2O	2·65	2·64	2·25	2·60	1·99
K_2O	6·00	3·07	3·14	3·42	5·19
H_2O	0·42	0·36	1·91	1·16	..
TiO_2	0·44	0·77	tr.	0·85	..
MnO	0·05	0·03	0·07	tr.	..
P_2O_5	1·12	0·02	tr.	0·09	..
Cl	..	..	..	..	..
Total ..	99·82	100·69	100·70	99·95	..
Sp. Gr. ..	2·67	2·66	2·68	2·68	..

I.—Porphyritic marginal phase of the granodiorite, South Morang. (Analyst: A. B. Edwards)

II.—Quarry Hill granodiorite, South Morang. (Analyst: F. J. Watson).

III.—Bulla granodiorite. (Analyst: F. J. Watson) (James, A., 1920).

IV.—Mt. Gellibrand "adamellite", Broadmeadows. (Analyst: H. C. Richards) (Stillwell, F. L., 1911).

V.—Metamorphosed Silurian shale adjacent to porphyritic granodiorite.

PORPHYRITIC MARGINAL PHASE OF THE GRANODIORITE.

The marginal portion of the granodiorite in the eastern outcrop is pronouncedly porphyritic, the phenocrysts consisting of anhedral orthoclase crystals which are up to 3 inches long and 1 to 2 inches wide.

This border phase appears to be purely local as shown in fig. 2, but it may extend along the roof and walls of the stock as suggested in fig. 5.

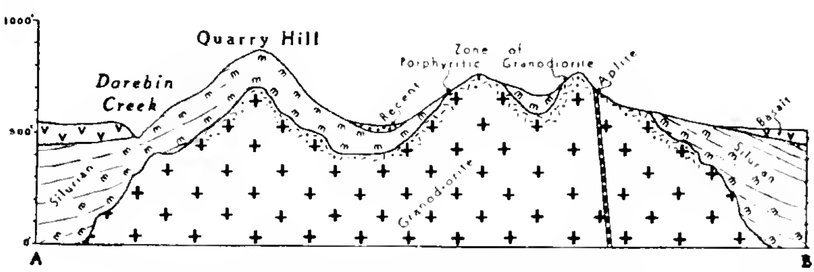

Fig. 5.—Geological sketch section through Quarry Hill, showing probable space form of the granodiorite, porphyritic zone and relationship to the invaded Silurian country rock.

The orthoclase phenocrysts show a random arrangement, and are not at all corroded. They contain lamellar perthite intergrowths of albite, and poikilitically enclose crystals of biotite, oligoclase, quartz, zircon, apatite, ilmenite, muscovite, andalusite

and garnet. The andalusite is derived from the disintegration of xenoliths of the sillimanite-andalusite hornfels, while the garnet is a reaction product of the granodiorite magma with the ferromagnesians of the xenoliths (Edwards, 1936, p. 44).

The groundmass of the border phase consists of contaminated granodiorite. In it oligoclase predominates over orthoclase, and associated with these minerals are biotite, muscovite, garnet, brookite, andalusite, corundum and diopside. In addition, there are numerous remnants of granitised xenoliths. Much of the biotite is a reddish-brown colour, and resembles that in the hornfels, from which, presumably, it is derived, as also are certain quartz grains containing clouds of dust-like inclusions. In parts of the marginal zone, abundant muscovite is mainly derived from the assimilation of muscovite hornfels at the adjacent contact, as is the andalusite and corundum. These portions of the granodiorite also contain a pale green mica, reddish-brown biotite, and xenocrysts of material identical with the sillimanite-mica idioblasts found in the nearby sillimanite-andalusite hornfels. The pale-green mica has been formed by the bleaching of biotite, and the titanium, which was taken up by the biotite during its development under thermal metamorphism, has been thrown down as rutile needles in the cleavages, where it forms sagenitic webs.

A chemical analysis of the marginal phase (Table 2, No. 1), shows that it is distinctly richer in potash, and in phosphorus, than the normal granodiorite (Table 2, No. 2), and that it is poorer in lime, but otherwise has many features in common with it.

The enrichment in potash can have developed in either of two ways. It may represent a marginal concentration of potash-rich residual magma, or it may have arisen through the assimilation of potash-rich sediments by a magma almost at rest. The abundance of xenocrystic matter in the marginal phase, and the established potassic character of the adjacent contact sediments leaves little doubt that part at least of the potash was derived from this second source.

The replacement of orthoclase by oligoclase, and of biotite by hornblende, in certain of the xenoliths in the granodiorite away from the porphyritic margin indicates that the granodiorite magma as a whole was more or less undersaturated with respect to K_2O, since it could take additional K_2O into solution without immediately reprecipitating it as potash minerals. Occasional coarse crystals of orthoclase do occur through the main mass of granodiorite, suggesting that the degree of undersaturation was only slight, but they are neither as large nor as abundant as those in the marginal zone. Presumably, therefore, the magma was

sufficiently fluid for the potash obtained from the xenoliths to be more or less evenly distributed through the magma by diffusion and by convection currents.

The size of the phenocrysts of orthoclase in the marginal zone, coupled with their late formation, indicates that they must have crystallized rapidly. This establishes that the marginal zone, unlike the core magma, was saturated with K_2O, and that addition of extra K_2O from the assimilated xenoliths led to its rapid re-precipitation as orthoclase.

As long as xenoliths could migrate into the interior of the granodiorite stock, their potash content could be dispersed through a considerable volume of magma, and the increase in potash at any one point would be slight, and without any marked effect; but with a cessation of such movement, any potash added would accumulate in the limited volume of magma adjacent to the contact, where saturation would soon develop, and lead to re-precipitation of the potash.

In the marginal zone, the lack of parallel arrangement of the orthoclase crystals, and the abundance of xenocrystic "strew" indicates that the magma was not subject to convectional currents or differential movements, and had lost the fluidity which enabled earlier formed xenoliths to sink or be swept out into the interior of the stock, so that there was no strong force which would sweep away the products of the assimilation that was clearly in progress. Moreover, the apparent loss of fluidity would suggest a restricted range and rate of diffusion for dissolved substances such as potash, which would then develop local over-saturation and precipitate as large phenocrysts of orthoclase. Such a cessation of movement, and reduction of fluidity might be expected to develop at the margin as the stock cooled.

Dykes and Veins.

Occasional aplite veins from 1 to 20 feet wide traverse the granodiorite, and more rarely the contact rocks. They can be traced for only short distances. Aplite also forms occasional patches and stringers threading through the granodiorite. The aplites have fine to coarse saccharoidal textures, and consist chiefly of orthoclase, interlocked with quartz crystals, and with lesser amounts of idiomorphic oligoclase, scattered plates and radial aggregates of muscovite, occasional plates of altered biotite, and rare crystals of ilmenite, apatite and zircon. Fine-grained, graphic pegmatite of much the same composition occurs as scattered boulders near the eastern margin of the eastern granodiorite contact, and small veins of quartz, seldom more than 3 inches wide, are occasionally present. Small amounts of orthoclase are associated with the quartz in vughs in these veins.

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[Proc. Roy. Soc. Victoria 56 (N.S.), Pt. I, 1944.]

Art. III.—*Ecological Studies No.* VII. *Box-Ironbark Association.*

By REUBEN T. PATTON.

[Read 8th July, 1943; issued separately 1st August, 1944.]

Introduction.

The Box-Ironbark forests of the State consist of the Red Ironbark, *Eucalyptus Sideroxylon*, White Ironbark, *E. leucoxylon*, and Grey Box, *E. hemiphloia*. In places, other species may be present, as Red Box, *E. polyanthemos*, Red Stringybark, *E. macrorrhyncha*, and less commonly Long-leaved Box *E. elaeophora*, but these three belong to another association which replaces Box-Ironbark as rainfall increases. Another species Yellow Box, *E. melliodora*, may also occur, but its presence usually indicates a local change in soil conditions and as a rule it is accompanied by a greater amount of grassland.

The Box-Ironbark forests extend discontinuously along the northern foothills of the Divide from Chiltern in the north-east to Stawell in the west. The three trees constituting the association have individually much wider distributions than in the Box-Ironbark forests themselves and are to be found in widely differing habitats.

Grey Box is also essentially a tree of the grasslands of the north where it forms true Savannah. Nearer the foothills of the Divide, the trees come so close together as to constitute Savannah Forest. It is impossible to mark a boundary between this type of forest and true forest. Grey Box is associated with grassland from regions near Tallangatta in the north-east to the south western boundary of the Wimmera. It does not extend southward into the higher elevations but it is only a few miles from the top of the Divide at the Kilmore Gap. Grey Box, however, reappears to the south of the Gap at Broadmeadows where it is again associated with grassland. It occurs at Melton and from there it extends for a few miles both to the south and west of Bacchus Marsh. Grey Box is limited to these restricted areas south of the Divide although grasslands are there abundant.

White Ironbark, which is sometimes known as Yellow Gum, also has a wide distribution north of the Divide, although more restricted than Grey Box. It is plentiful at Mangalore in the east and extends westwards to the Wimmera where it joins Grey Box on the grasslands. White Ironbark, however, is not found with Grey Box on the northern plains. South of the Divide, White Ironbark has a very limited range. It is found in the

Plenty River area and appears again north-west of Melton where it is associated with Grey Box but a characteristic Box-Ironbark forest does not develop. White Ironbark extends southwards along the eastern side of the Brisbane Ranges and is found as far west as Meredith where it occurs on grassland.

Red Ironbark, on the north of the Divide, unlike the other two tree members, is restricted to the association, but in the south it has a very extensive and very curious disconnected distribution. The climatic conditions of some of these southern localities are widely different from those of the northern areas. In the east of the State, Red Ironbark is fairly plentiful at Gipsy Point, on Mallacoota Inlet, and a few trees occur about 3 miles west of Cann River township. From Orbost to Bairnsdale it is plentiful in places, and here both Red Box and Red Stringybark also occur. Further west it also occurs at Toongabbie. To the north-east of Melbourne, Red Ironbark is fairly common in the Panton Hill district, where it again associates with Red Box and Red Stringybark. To the west of Melbourne there is a localized occurrence of rather stunted trees on the hills to the north of Melton, and further west it appears again at Ingliston, just beyond Bacchus Marsh. It is reported to occur in the forest to the south of Ballarat, but the author has not been able to confirm this. In the Melton area, although both Grey Box and White Ironbark are present, they do not mix with Red Ironbark. In view of the hot dry summers and the continental climate generally experienced north of the Divide, these occurrences of Red Ironbark in the south are surprising, but still more so is the presence of this species right at the seaside where it is under the influence of an oceanic climate. To some extent the presence of it at Jemmy's Point, Lakes Entrance, may not be wondered at as it occurs plentifully immediately to the north. However, the occurrence at Airey's Inlet, in the Otway Peninsula, is widely separated from any other.

This association is of great economic importance, since the three trees constituting it, provide very heavy durable timbers and excellent firewood. They also occupy areas which are quite unsuitable for any other purpose, on account of the stony ground. The Box-Ironbark forests are of interest since in many instances they are immediately succeeded on the northern side by patches of Mallee although the main block of the Mallee is very distant and occurs on a very different type of soil. These isolated patches of Mallee occur on the same geological formation as the Box-Ironbark and immediately adjoin. Often Red Ironbark penetrates these patches of Mallee scrub. The contrast in height from Box-Ironbark to Mallee scrub is very striking, and no satisfactory evidence is as yet forthcoming to give any explanation for the sudden change in the several occurrences. Mallee is associated with the Box-Ironbark Association at Rushworth, Bendigo, Ingle-

wood, Wedderburn, and St. Arnaud. It is of interest that just to the west of Melton where the three tree members of the association occur there is also a patch of Mallee, the only occurrence south of the Divide.

Nearer to the Divide the Box-Ironbark is succeeded by the Red Box-Red Stringybark association which is also strongly developed south of the Divide. Generally speaking the trees of this latter association, although growing under more favourable climatic conditions, are smaller in height than those of the Box-Ironbark association. The distribution of the various occurrences of the association is shown in fig. 1. This paper chiefly concerns itself with a general survey of the whole area where Box-Ironbark occurs and where detailed studies have not yet been made.

Physical Environment.

Climate.

Rainfall.

All the individual occurrences of Box-Ironbark receive very similar amounts of rainfall, although they are spread over an area some 225 miles long by a maximum width of about 62 miles. The greatest amount is received by the most easterly area of the association. The annual rainfall received by the various Stations situated in the Box-Ironbark areas (fig. 1) is given in Table 1.

Table I.—Annual Rainfall of Stations in Box-Ironbark Areas.

Station.	Mean Annual Rainfall.
Chiltern	26·75 inches
Peechelba	23·46 ,,
Rushworth	19·96 ,,
Heathcote	22·48 ,,
Bendigo	21·24 ,,
Maldon	23·17 ,,
Inglewood	18·07 ,,
Dunolly	19·98 ,,
Maryborough	20·34 ,,
Talbot	21·25 ,,
Wedderburn	18·68 ,,
St. Arnaud	19·36 ,,
Stawell	21·27 ,,

It will be seen from Table 1. that the annual rainfall varies from slightly over 18 inches to less than 24 inches with the exception of Chiltern, which lies close to the Eastern Highlands. The southern limit of this association is definitely fixed by climatic conditions, for, where the same soil conditions continue into the higher rainfall and cooler temperature areas, the Box-Ironbark is replaced by Red Stringybark-Red Box association. The northern limits are not well defined for here the boundary is often fixed by a

change in the geology. The presence of Mallee, however, on the northern side of several of the occurrencs of this association does suggest that a climatic limit had been reached. None of these patches of Mallee is extensive, and they are soon succeeded by grassland.

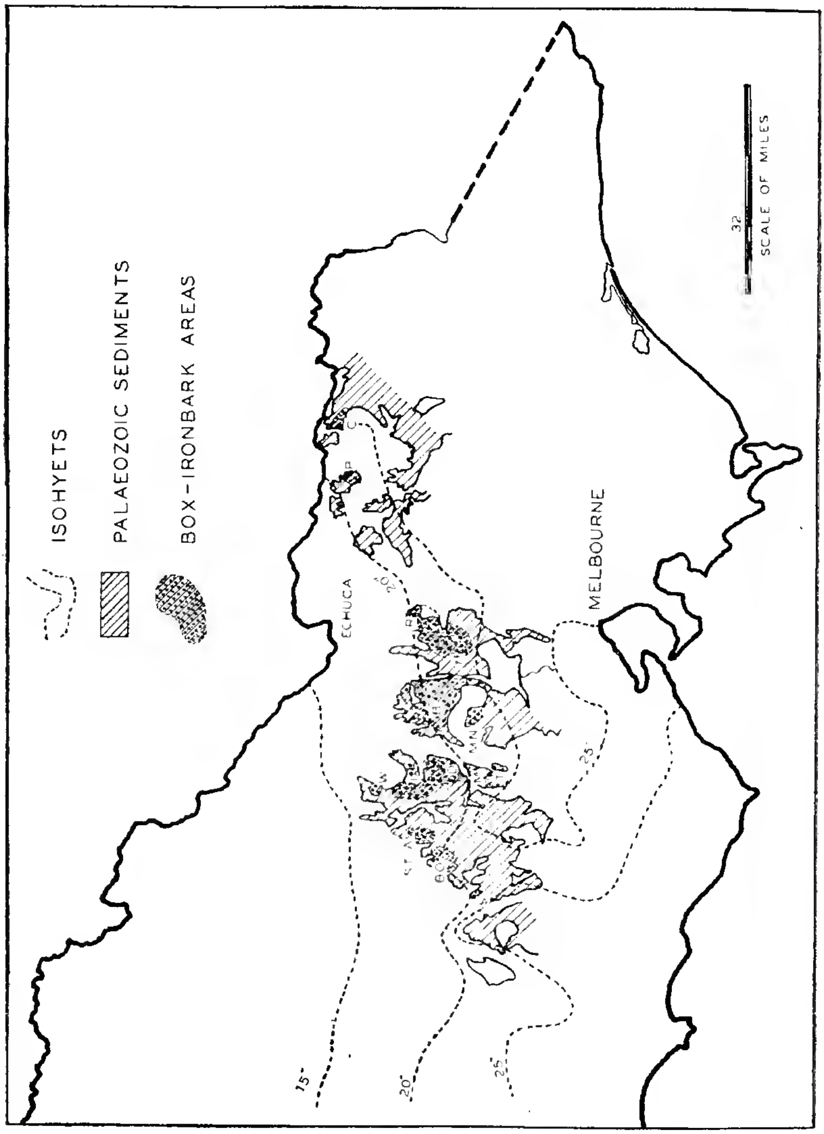

Fig 1.—Distribution of Box-Ironbark Areas in Victoria. B = Bendigo, Bo = Bolangum, C = Chiltern, D = Dunolly, H = Heathcote, I = Inglewood, M = Maryborough, Mn = Maldon, P = Peechelba, R = Rushworth, S = Stawell, St. A. = St. Arnaud, T = Talbot, W = Wedderburn.

The distribution of rainfall over the year is distinctly of a winter type, but this is by no means pronounced. In the southern half of the State an even distribution of rain occurs, as shown by Melbourne records. In fig. 2 is shown a graph of the monthly distribution for Bendigo, which is typical of the remaining Stations. The distribution is also given for Melbourne for comparison.

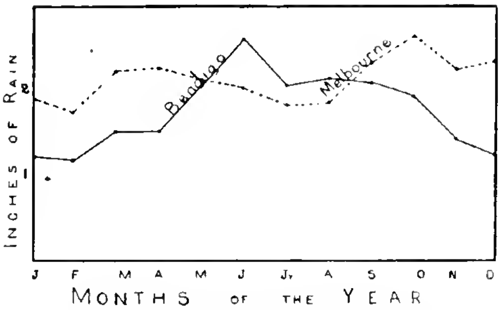

Fig. 2.—Monthly Distribution of Rainfall for Bendigo and Melbourne.

The actual and relative amounts of rainfall received during the six summer months, October to March, and the six winter months, are given in Table II. for selected Stations, which may be regarded as typical of the remainder. Rainfall is approximately half as much again during the winter as in the summer months.

Table II.—Ratio of the Rainfall of the Six Summer to the Six Winter Months.

Station.	Rainfall for Six Months.		Ratio.
	October March.	April September.	
Bendigo	8·64	12·60	1 : 1·46
Maryborough	8·18	12·16	1 : 1·49
St. Arnaud	7·16	12·20	1 : 1·70
Stawell	8·05	13·22	1 : 1·64

Besides the annual amount of rain and its yearly distribution, the regularity with which it is received year by year is also a factor in the development and character of the vegetation. In Table III. are given the Coefficients of Variability for selected Stations. These values represent a reasonable degree of reliability when compared with a 34.5 per cent. variability for Mildura and 12.3 per cent. for Portland.

Table III.—Coefficient of Variability of Rainfall in Box-Ironbark Areas.

Station.	Co-efficient of Variability.
	%
Bendigo	24·5
Maryborough	22·33
St. Arnaud	21·71
Stawell	21.43

TEMPERATURE.

Temperature must also be considered from two standpoints, Average Annual Temperature and the Monthly Distribution.

As with the case of rainfall, the temperatures of the various Stations are closely similar. In Table IV. are given the annual temperature of the same stations shown in Table III.

TABLE IV.—MEAN ANNUAL TEMPERATURES OF SELECTED STATIONS IN BOX-IRONBARK AREAS.

Station.	Annual Temperature.
Bendigo	59·0°F
Maryborough	57·4°F
St. Arnaud	58·1°F
Stawell	57·9°F

The monthly distribution of temperature indicates that north of the Divide the climate is becoming decidedly continental. Several of the cooler months of Stations in the Box-Ironbark areas are colder than those of Stations along the coast, and in fig. 3 are given the graphs of Bendigo and Lorne for comparison. Lorne is selected because it is not far from Airey's Inlet where Red Ironbark occurs. The six winter months of Melbourne are also warmer than the same six months of Bendigo. However, the summer months of the latter are very much warmer. The graph for Bendigo is typical of the other stations.

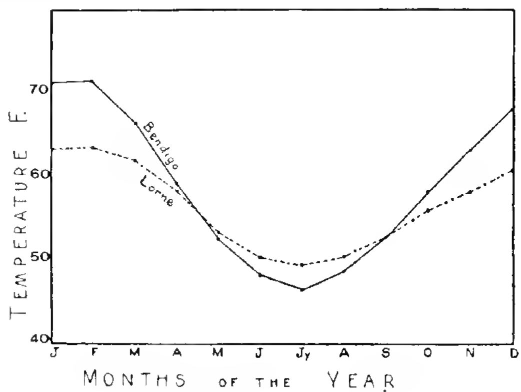

FIG. 3.—Monthly Distribution of Temperature for Bendigo and Lorne.

The highest temperatures occur during February, and this is the same for all other stations, while the lowest are in July. This makes the graph asymmetric since there are only five months from the peak of summer to the trough of winter. The range of monthly temperatures for Bendigo is 25.1° F., and the lowest range for Box-Ironbark is 22.7° F. Lorne having an oceanic climate has a range of only 15° F.

EVAPORATION.

There are no Stations recording evaporation near any of the Box-Ironbark forests, and the values given in Table V. have been calculated from other weather data. These indicate that the average annual evaporation lies approximately between 45 and 50 inches.

TABLE V.—ANNUAL EVAPORATION IN BOX-IRONBARK FORESTS.

Station.	Annual Evaporation (calculated).
Bendigo	50·53 inches
Maryborough	45·95 ,,
St. Arnaud	50·80 ,,
Stawell	46·44 ,,

The monthly distribution of evaporation is naturally affected by the continental character of the temperature range. In fig. 4 is given the monthly distribution of evaporation for Bendigo.

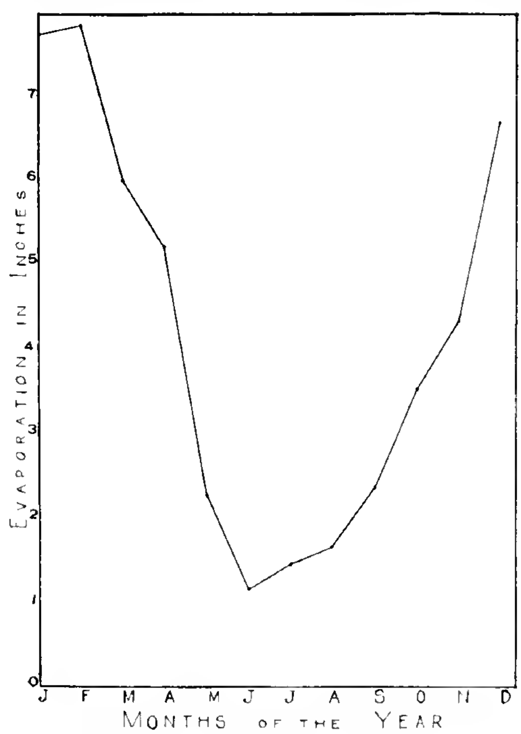

FIG. 4.—Monthly Distribution of Evaporation for Bendigo.

Summary of Climate.

The general features of the climate in the Box-Ironbark areas agree fairly well with the chief characteristics of that of the Mediterranean, as outlined by Kendrew (1937). Kendrew observes that most of the rainfall occurs in the winter half of the year and that in summer there are more or less drought conditions, which do not last more than three months. As will be shown later there is an absence of floral activity for about three months of the year. Kendrew also says that the winters are mild, the coldest month having a mean temperature above 40°F. Of all the Stations in the Box-Ironbark areas where temperature records are kept, the lowest monthly mean is 45.1°F. at Maldon; in summer the warmest monthly mean exceeds 70°F. This also agrees reasonably well with the January temperatures of all the Box-Ironbark stations. For Box-Ironbark the lowest January mean temperature, the month in our climate corresponding to July in the northern hemisphere, is 67.5°F. at Maldon. In all cases where temperature is recorded February is the warmest month.

The third characteristic is the clear, sunny, almost cloudless sky during summer. This is a feature of our areas north of the Divide and requires no comment. Kendrew regards the Olive Tree as one of the most characteristic of the Mediterranean vegetation. This has evergreen leathery leaves, a feature characteristic of our eucalypts.

These climatic conditions are reflected in the vegetative and floral activity of the Box-Ironbark association. Plant life is dormant for about three months corresponding to the three drought months indicated by Kendrew. After the drought is over the lower temperatures retard, but do not inhibit, plant activity. In the closely allied Red Box-Red Stringybark association of the south, as shown by the author in 1937, the curve of flowering commences to rise from May; but in the Box-Ironbark there is little activity until after June. In other associations of the south, as shown by the author in 1933 and 1936, the curve of flowering is the same as in Red Box-Red Stringybark. In the southern examples of Red Box-Red Stringybark both August and September are very active months, but in the Box-Ironbark the amount of flowering in August and September is little more than in July. In both associations, the peak of flowering is in October with a very rapid fall to December, which in both instances is due to rising temperatures and declining moisture. In the climatic conditions at Bendigo, as with the other occurrences of Box-Ironbark, the length of the period of the year favourable to plant

activity is more restricted than in the associations given south of the Divide. In fig. 5 is shown the distribution of flowering over the year for Bendigo.

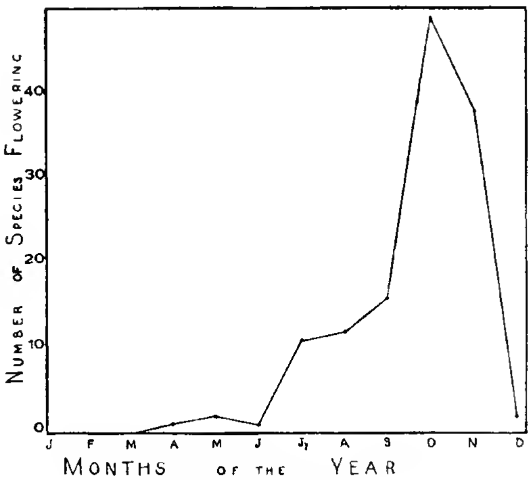

FIG. 5.—Monthly Distribution of Flowering Box-Ironbark Association.

GEOLOGY.

All the Box-Ironbark forests are situated to the north of the Central Highlands, the lower limit of these being taken for botanical purposes at 1,000 feet. The greatest elevation of any of the Stations for which climatic data were given is 818 feet, at Talbot, which is the most southerly point of the Box-Ironbark forests. Here they are limited both on the east and on the west by the long stretches of the newer basalt which connects with the basalt plains south of the Divide. The southward extension is prevented by the basalt so that the climatic limit has not been reached.

The contour of the land where the various examples of this association occur is never very steep, but fairly gentle. Hence, neither the degree nor the aspect of the slope is a factor influencing the vegetation of the area.

It has already been mentioned that the Box-Ironbark forests are discontinuous, and that they are separated from one another by areas of natural grassland or savannah. In the long stretch of country through which the various stands of Box-Ironbark are situated there are four geological formations of considerable

extent, namely Granite, Ordovician, Newer Basalt and Post-Tertiary Sediments. There is a broad belt of Newer Basalt running up from the south, nearly across the Western Highlands which is strictly grassland; the surface is flat and the soil is well developed. The Post-Tertiary Sediments belong to the Murray River system, and although they are essentially grassland, they vary from treeless plain to Savannah forest. West of Stawell there is a large area of Post-Tertiary deposits which is a continuation of the Wimmera grasslands, but which is dominated by a forest of Grey Box and White Ironbark. There is no Red Ironbark present, and therefore this area has not been included in fig. 1. Both of the first two mentioned species pass out into the grassland to form Savannah. Wherever the trees steadily increase in density, the character of the grass floor is not lost and when the land is cleared good grassland results. These Savannah forest areas may best be regarded as a compromise between climatic and soil influences. This type of vegetation was extensive where the plains join the foothills of the Divide.

The Granite breaks down into a gravelly porous soil which, according to contour, bears two different types of vegetation. To the east of Chiltern it is covered with Red Box and Red Stringybark, with a strong admixture of *Callitris calcarata*. This is a very special variation of the Red Box-Red Stringybark association so common in the State. Granite immediately adjoins the Peechelba stand, but this is also clothed with Red Box-Red Stringybark. In both of these areas the country is sharply contoured and, taken generally, mountains are covered with forest.

South of Bendigo at Big Hill where the granite commences there is a sudden termination of the Box-Ironbark association. The granite country is generally grassland and gently undulating, with scattering trees, among which is River Red Gum *Eucalyptus rostrata*. East of Castlemaine where it rises into Mount Alexander it is forest clad. South of the granite outcrop the Box-Ironbark again appears from Maldon to Castlemaine, so that the granite here has this association on both sides of it.

The fourth geological formation, the Palaeozoic Sedimentary rocks, is the home of the Box-Ironbark. Not every outcrop, however, bears this forest, for it too may carry open forest, with a grass floor where it has a very flat contour and adjoins grassland. It is difficult to speak of soil in the ordinary usage of the word, for but little exists. The rock lies at or near the surface, and therefore the roots of the plants must pass into the disintegrated rock or even between the strata. At the bottom of the

slopes in hilly or undulating country, there is an accumulation of clay, and here one may speak of soil in the ordinary sense. The upper slopes may be very stony. In places quartz lies freely on the surface and these areas can be practically destitute of lower vegetation.

Composition.

One of the remarkable features of the Box-Ironbark association is the large number of species that are very rare or infrequent, but which are common in associations having a higher rainfall and a lower temperature. Many plants common south of the Divide as *Leucopogon virgatus, Daviesia ulicina, Dillwynia floribunda, Correa rubra, Leptospermum myrsinoides, Lomandra filiformis, Drosera Menziesii, Plantago varia* and *Craspedia uniflora* are in this association, but are sparsely represented, and this is due to the fact that they are reaching their limits of distribution or that conditions are very unfavourable for their free development.

Other species which are common in other associations, as well as here, represent those which have a wide amplitude as regards habitat factors. These ubiquitous species have been designated as ecological wides, Patton (1930). Such species, being found in a number of associations, are said to possess a very low degree of fidelity to any particular one. Among these are *Poa caespitosa, Dianella revoluta, Dichopogon strictus, Glossodia major, Ranunculus lappaceus, Tetratheca ciliata, Wahlenbergia gracilis* and *Microseris scapigera*. Such species, existing as they do under widely differing conditions, may be expected to show a great deal of variation, and this is the case with *Poa caespitosa* and *Wahlenbergia gracilis* but not with others. The question arises as to whether these different forms are actual species and not varieties. The separate forms, however, may be ecotypes.

Those species, which very definitely distinguish an association, are known as Characteristic Species. Besides the three species of Eucalyptus there are others which are equally distinctive. These characteristic species may be confined to a particular association and therefore show a high degree of fidelity to it. On the other hand, a species may be equally well developed in another association and there also characteristic of the second. In such instances as the latter the species show a lower degree of fidelity. Thus *Acacia acinacea* and *A. diffusa* are characteristic both of Box-Ironbark and Red Box-Red Stringybark associations. On the other hand *A. pycnantha* (Golden Wattle), is perhaps the most characteristic species and shows a high degree of fidelity. Other characteristic species are *Grevillea alpina, G. ilicifolia, Brachyloma daphnoides* and *Eriostemon obovalis*.

Another feature of the vegetation, but by no means a obvious one, is the number of very small annuals that occur. Such small plants are best spoken of as Minutae. The presence or absence of these, their abundance, and the degree of development are controlled by the weather in any particular year. So small are many of these plants that as many as four species have been found in a single square inch. Among the Minutae are *Levenhookia dubia, Toxanthus Muelleri, Millotia tenuifolia* and *Helipterum demissum.*

In the Box-Ironbark Association there is a good representation of the most prolific families and genera of Victoria. Of the ten most prolific families given by Patton (1935), no less than eight are present. The two families which are absent have rather specialized habitats, and therefore their absence occasions no surprise. Of the fifteen genera with the greatest number of species in Victoria, twelve are present. The absence of Olearia is a matter of interest since this genus is abundantly present from the wettest to the driest parts of the State, so that apart from this genus, the flora of the Box-Ironbark association is therefore quite representative of the State.

The family Myrtaceae provides the three dominants of the association, but other than these it is poorly represented. *Leptospermum myrsinoides*, which is very rare, is the only other representative. At Maryborough *Calytrix tetragona* is locally abundant. The family Epacridaceae is very well represented by no less than five genera and six species; only one genus Leucopogon, however, has more than one species present. Of the six species of this family only one, *Brachyloma daphnoides*, is abundantly present. All species have small, thick, leathery leaves.

There is only one genus, Grevillea, of Proteaceae and this has two species present. *G. alpina* has usually a red flower, but a white variety regularly occurs, which is said to be the only form present at Rushworth. The genus Acacia is the most important member of Leguminosae. At the type area there are five species present, and three of these *A. acinacea, A. armata,* and *A. vomeriformis* possess very similar characters. The inflorescence is a globular head and the phyllode is small and uninerved.

To the east of Bendigo, in the Box-Ironbark forests as well as in other areas, two other closely related species *A. aspera* and *A. obliqua* occur, while to the north in the Whipstick Mallee are two more closely related species, *A. brachybotrya* and *A. lineata,* the

latter being recorded by Patton in (1924). Six of these species may be regarded as being derived from the simple common form, *A. acinacea*, in which the phyllode is symmetrical, or almost so, narrow and about half an inch long. *A. armata* has an undulate phyllode, and the stipules are developed into spines. In *A. aspera* the phyllode is slightly undulate and it is covered with glandular hairs which make it very rough. The phyllode of *A. brachybotrya* is generally slightly longer than in *A. acinacea* and broader in proportion to its length. The surface is covered with soft pubesence, making it very glaucous. In the remaining three, asymmetry which is more or less present in the others, becomes marked. In *A. vomeriformis* the asymmetry takes the form of one side of the phyllode being developed into a triangular lobe at the base, while in *A. obliqua* one side is shortened. The asymmetry in *A. lineata* is caused by one side of the phyllode failing to develop thus bringing the midrib near to one edge. The suggested relationship of all these species is given in fig. 6.

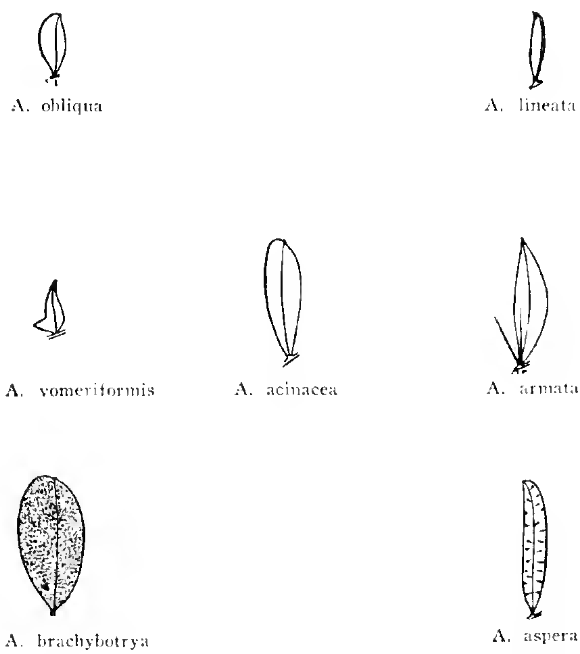

FIG. 6.—Relationship of species of Acacia with small Uninerved Phyllodes (natural size).

The species given in the following list have all been collected at Bendigo, between Kangaroo Flat and Big Hill, and for a distance about 2 miles west of the Highway. This area is taken as the type of the Association. Species found in other parts of the Bendigo district are not given.

MONOCOTYLEDONAE.

GRAMINEAE—
Stipa Drummondii
S. scabra
S. mollis
Dichelachne crinita
D. sciurea
Danthonia geniculata
D. pallida
D. semiannularis
Aira caryophyllea
Poa caespitosa

LILIACEAE—
Burchardia umbellata
Anguillaria dioica
Bulbine bulbosa
Thysanotus Patersonii
Dichopogon strictus
Tricoryne elatior
Dianella revoluta
Lomandra filiformis

AMARYLLIDACEAE—
Hypoxis glabella

ORCHIDACEAE—
Calochilus Robertsonii
Cyrtostylis reniformis
Caladenia carnea
C. coerulea
C. praecox
C. testacea
Glossodia major
Diuris maculata
Pterostylis cycnocephala
P. longifolia
P. nana
P. nutans
P. parviflora.

DICOTYLEDONAE.

ARCHICHLAMYDEAE.

PROTEACEAE—
Grevillea alpina
G. ilicifolia

SANTALACEAE—
Exocarpus cupressiformis

CHENOPODIACEAE—
Rhagodia nutans

CARYOPHYLLACEAE—
Sagina apetala

RANUNCULACEAE—
Ranunculus lappaceus
R. parviflorus

LAURACEAE—
Cassytha glabella

DROSERACEAE—
Drosera auriculata
D. Menziesii
D. peltata
D. Whittakeri

CRASSULACEAE—
Crassula Sieberiana
C. micrantha

PITTOSPORACEAE—
Bursaria spinosa
Cheiranthera linearis

ROSACEAE—
Acaena ovina

LEGUMINOSAE—
Acacia acinacea
A. armata
A. aspera
A. diffusa

LEGUMINOSAE—*continued*
A. vomeriformis
A. pycnantha
Daviesia ulicina
Pultenaea largiflorens
P. laxiflora
Dillwynia ericifolia
D. floribunda
Hardenbergia monophylla

GERANIACEAE—
Geranium pilosum
Pelargonium Rodneyanum

OXALIDACEAE—
Oxalis corniculatus

RUTACEAE—
Eriostemon obovalis

TREMANDACEAE—
Tetratheca ciliata

DILLENIACEAE—
Hibbertia acicularis
H. sericea

THYMELAEACEAE—
Pimelea humilis
P. involucrata

MYRTACEAE—
Eucalyptus Sideroxylon
E. leucoxylon
E. hemiphloia
E. melliodora
E. macrorrhyncha
E. polyanthemos
Leptospermum myrsinoides

UMBELLIFERAE—
Daucus glochidiatus
Hydrocotyle capillaris
H. laxiflora.

METACHLAMYDEAE.

EPACRIDACEAE—
Astroloma humifusum
Melichrus urceolatus
Leucopogon virgatus
L. rufus
Acrotriche serrulata
Brachyloma daphnoides

GENTIANACEAE—
Sebaea ovata

SCROPHULARIACEAE—
Veronica plebeia

PLANTAGINACEAE—
Plantago varia

CAMPANULACEAE—
Wahlenbergia gracilis

GOODENIACEAE—
Goodenia geniculata
Brunonia australis

STYLIDIACEAE—
Stylidium graminifolium
Levenhookia dubia

COMPOSITAE—
Brachycome perpusilla
Craspedia uniflora
Toxanthus Muelleri
Rutidosis multiflora
Millotia tenuifolia
Leptorhynchus squamatus
Helichrysum bracteatum
H. obcordatum
H. semipapposum
Helipterum australe
H. demissum
Gnaphalium indutum
Erechthites quadridentata
Microseris scapigera

Structure.

The structure of the association is simple. The trees stand well apart from one another (Plate 1) so that their crowns do not meet. Thus ample light reaches the forest floor, but the entry of light is further assisted by the habits of the trees themselves. Grey Box is a fairly tall tree commonly with the two main branches forming a capital Y (Plate 1). The foliage is restricted to the ends of the ultimate branchlets and is not dense (Plate 1). Such a habit enables a great amount of light to filter through the crown and reach the forest floor. White Ironbark has no distinctive habit of branching, but the crown is not very dense and this enables light to pass through.

Red Ironbark, however, has an entirely different habit. Typically, the lateral branches of young to middle-aged trees are short and emerge at a very wide angle. Old trees become very scraggy. The foliage is borne right along the trunk (Plate 1), so that in an open grown specimen the tree presents the form of a narrow cylinder. Thus very little shade is cast. Both Grey Box and Red Ironbark, by their habit of growth, are favourable for the growth of an abundant shrub and ground flora, but these lower strata, however, are not strongly developed. There is no second stratum of trees, but occasionally isolated specimens of *Exocarpus cupressiformis* are present. At times *Acacia pycnantha* is abundant and forms a very open tall shrub or very small tree stratum. When in full bloom the golden flowers are strikingly contrasted against the dark stems and dull green crowns of the dominant trees. *A. diffusa* grows nearly as tall as the Golden Wattle, but is not so plentiful. Even when these two Acacias are present there is still an abundance of light reaching the forest floor. The degree of development of the medium shrub and undershrub strata varies widely. At times, the surface of the soil is quite bare even though the trees are spaced widely enough apart for full light to reach the ground. In such cases quartz is frequently very

abundant at the surface. In contrast to this, the medium shrub stratum may be strongly developed and give the soil complete or almost complete cover. The members of this layer are the characteristic species *Brachyoma daphnoides* and *Grevillea alpina.* This stratum is particularly well developed on rising stony ground where Red Ironbark predominates. On the lower slopes, Grey Box may be in a pure stand, and here the soil has a high percentage of clay. In such places the two characteristic shrubs are generally absent. The shrub stratum is therefore very discontinuous. Of the undershrubs, *Hibbertia acicularis* forms very dense bushes which are covered with a brilliant mass of yellow flowers in spring. This undershrub story is also very incomplete and therefore there is a large percentage of the soil exposed to the weather. Although there are a number of grass species present, none are abundant, and. therefore, do not assist in forming a soil cover.

Geophytes are fairly common, particularly in the spring, but they do not have much influence as regards soil cover. Two orchids *Glossodia major* and *Caladenia testacea* are very abundant in some years and give tinges of colour to the landscape. The forest then is very open and the ground cover very incomplete. The protection of the soil is further decreased by the small ericoid leathery leaves of the shrub strata, with the exception of *Grevillea ilicifolia.* Associated with the poor cover of the soil is the slowness of decay of debris from the trees, the amount of humus reaching the soil is therefore small.

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Description of Plate.

PLATE I.

Fig. 1. Box-Ironbark Forest with absence of lower strata, soil very gravelly.
Fig. 2. Box-Ironbark Forest with lower strata well developed, consisting partly of re-growth of eucalypts.
Fig. 3. Red Ironbark, Eucalyptus sideroxylon.
Fig. 4. Bark of Red Ironbark.
Fig. 5. Bark of Grey Box.
Fig. 6. Grey Box, E. hemiphloia.

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[PROC. ROY. SOC. VICTORIA 56 (N.S.), PT. I., 1944.]

ART. IV.—*Superficial Sand Deposits between Brighton and Frankston, Victoria.*

By SYLVIA WHINCUP, B.Sc.

[Read 8th July, 1943; issued separately 1st August, 1944.]

Abstract.

Four types of sand formations are described: (1) Longitudinal dune ridges which occur with great regularity in the Brighton area; (2) irregular barchan dunes in the Frankston area; (3) coastal ridges in the low-lying area between Mordialloc and Frankston; (4) lunette ridges believed to have been formed on the northern sides of swamps between Brighton and Frankston.

The mode of formation of the deposits is deduced from their shape, orientation and extent, and the stratification and degree of sorting of the sand, while the heavy minerals present and the roundness of grains give an indication of the origin of the sand. Factors which have influenced the physiography of the area are: tectonic movements, forming the low-lying area now occupied by the swamp; climatic changes, leading to formation of dunes and their later preservation by vegetation; and changes in sea level, which have caused the formation of three successive coastal ridges, two of which are very close together behind the present coastline, and one further inland forming the boundary between Carrum Swamp and Dandenong Swamp.

Introduction.

The present investigation has been carried out in an attempt to elucidate the nature and origin of the various types of superficial sand ridges that occur between Brighton and Frankston. The sand ridges in the Brighton district were mapped from aerial photographs which covered the area as far east as Edithvale Road. The position of ridges and depressions could be determined reasonably accurately with the aid of a stereoscope, and most of the ridges were then examined in the field. In the areas not covered by aerial photographs, the boundaries between sand ridges and alluvial flats were mapped on the ground. There is a marked difference in the vegetation cover of the sand ridges and the alluvial flats, which is most noticeable in the south-eastern part of the area, where settlement has not been so close as further north. Here most of the sandy areas have been left uncleared, whereas the alluvial flats are used extensively for agriculture. The most striking feature of the natural vegetation is the presence of bracken on any low sandy area, which may otherwise be almost indistinguishable from the alluvial flats, on which bracken is never found.

Physiography.

On physiographic grounds, the area described is divisible into north-west, central and south-east sectors.

The North-Western Sector.

This includes the coastal plain of the Brighton district, which extends inland for 4-5 miles towards the low foothills of the Eastern Highlands along the Gippsland-road. In the south, it terminates along the northern edge of the low-lying swampy areas which comprise the central sector (see below). Between Brighton and Mordialloc, there is a regular series of long, low, parallel sand ridges with intervening swampy depressions, all of which have a north-westerly trend. They have been described by Hart (1913), who suggested that the formation of regular, parallel valleys was due to "lines of easy erosion" in the Tertiary rocks over which the present drainage system developed.

The ridges, however, have not been previously studied in detail. Hills (1940A) states that "sand ridges were formed on some of the sandy coastal plains, as for instance in the Moorabbin-Highett district" during periods of relative aridity in recent times, but the extent and remarkable regularity of the ridges and shallow depressions, which may be seen on the map (fig. 1) have not been generally realized.

Owing to their parallelism to the present coast, it might be suggested that the ridges are old beach ridges left behind during a retreat of the sea. No shells, waterworn pebbles or other evidence suggestive of beach deposits, however, have been found in association with these ridges, and it is considered, on evidence that will be discussed below, that they are of aeolian origin.

The sand ridges are symmetrical in cross-section and have relatively flat tops. Because of their age, however, any minor morphological details such as a sharp crest, or slight variations in the slopes on either side that might once have existed, may have been modified by erosion. In their straightness and regular parallel arrangement they resemble longitudinal dune ridges, such as have been described by Madigan in Central Australia (1936), and, although the Brighton ridges are broader and much closer together than the Central Australian ones, it seems probable that they were formed under similar conditions and are actually longitudinal dunes. Further to the east on the other side of the low divide referred to as the Cheltenham Axis by Hart (1913), the ridges become shorter and less regular, although the same north-westerly trend of the country is still apparent. The drainage here is in a south-easterly direction towards Carrum Swamp.

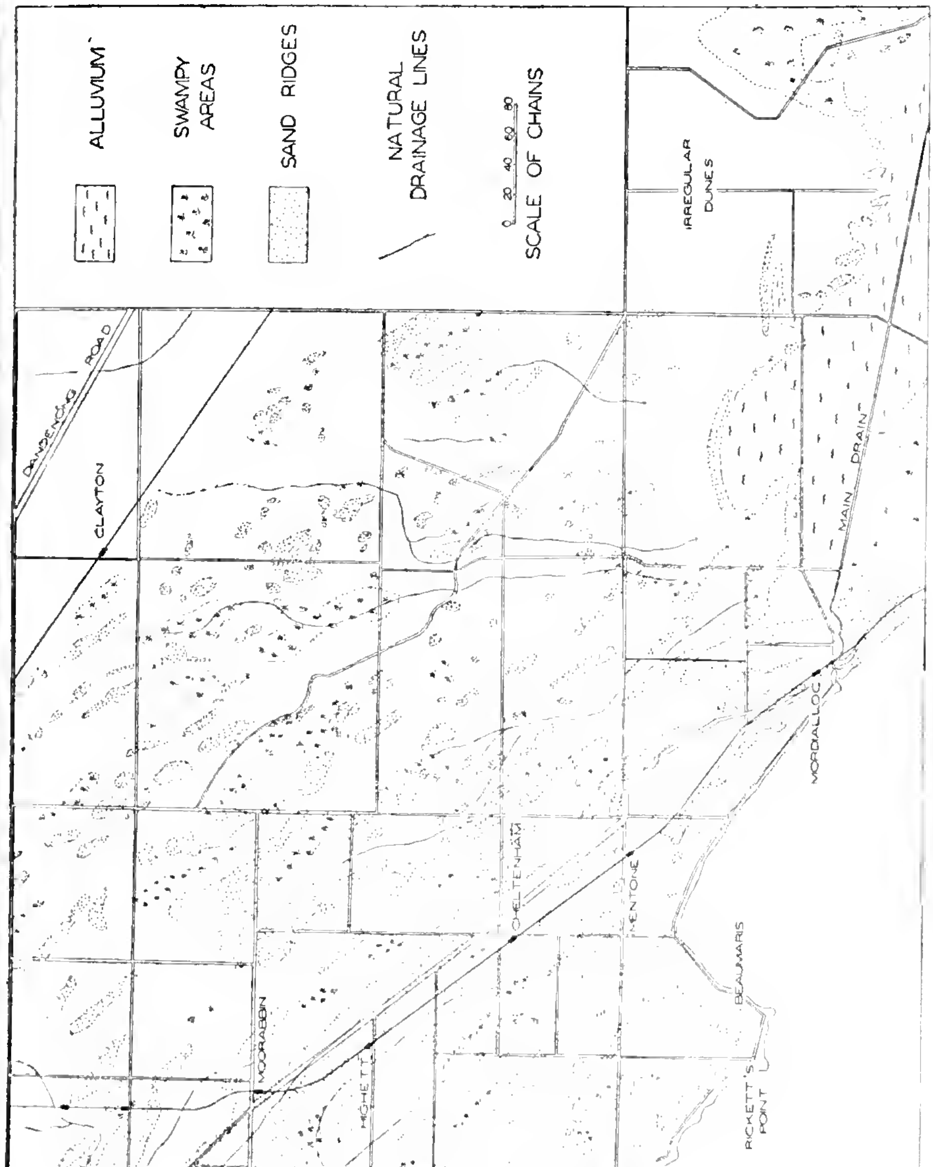

FIG. 1.—Map of Sand Ridges on the Coastal Plain between Brighton and Mordialloc.

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South-Eastern Sector.

This part of the area includes the country between Frankston, Carrum Downs and Cranbourne, over which extensive sand deposits are also found. In this sector, the land is higher and not as flat as in the Brighton district, and there is a marked difference in the external form of the sand ridges compared with those in the north-western sector.

Instead of the parallel ridges and valleys found in the north-west, individual sand hills are irregularly dispersed and do not cover the whole of the area. These sand hills are so crowded together and are so irregular in height and size, that their true form is hard to distinguish. They resemble barchans in that most of them are slightly curved and have a steeper face on the concave side, and will be referred to as such in this discussion. At the bottom of the steeper slopes, swampy areas, in which the vegetation is very thick in contrast with the heathy type of vegetation growing on the sand hills themselves, commonly occur.

The depth of sand in these deposits is much greater than in the longitudinal ridges in the north-west, 80-90 feet of sand being exposed in many of the pits along the Frankston-Cranbourne road.

Central Sector.

Between the above two sectors in which sand formations are widespread, is the flat and relatively low-lying area occupied by the Carrum and Dandenong Swamps. Carrum Swamp is separated from the sea by a continuous line of sand ridges parallel to and just behind the present coastline. Further inland, about 1½ miles from the coast at its greatest distance, a similar curved sand ridge forms the boundary between Carrum Swamp and Dandenong Swamp (see fig. 2). This ridge, along which Wells'-road runs, is more or less continuous from Mordialloc to Frankston, and has been referred to as Wells'-road Ridge (Hills, 1940B). The whole of the flat low-lying area extending inland from Wells'-road for about 5 miles will be referred to as the Dandenong Swamp.

Coastal Ridges.—Along the sweeping curve of the coastline between Mordialloc and Frankston, there are no cliffs such as are found to the north and south, the coast being composed entirely of sand. About 3 chains inland is a continuous ridge of sand of fairly uniform height, along which the Melbourne-Frankston railway line has been constructed. Between Mordialloc and Carrum there is only a single main ridge, behind which is a low sandy area descending towards the edge of Carrum Swamp. This ridge becomes wider towards Carrum and splits up into

two parallel ridges, between which Kananook Creek flows until it breaks through to the sea at Frankston. A diagrammatie cross-section through this part of the coast is shown in fig. 4.

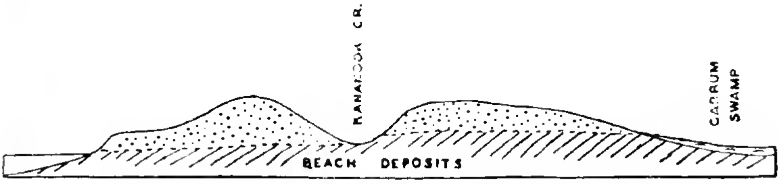

Fig. 4.—Diagrammatic Section through the Coastal Ridges at Seaford. (Not drawn to scale.)

As will be seen in the discussion of their lithology, these ridges are composed of wind-blown sand resting on beach deposits, and they are, therefore, "dune ridges" as defined by Johnson (1919).

Wells'-road Ridge.—This ridge is not as high nor as continuous as the one close to the beach, but it can be followed with some gaps in a curved line from the corner of Edithvale-road and Wells'-road until it joins the coastal ridges just north of Frankston. In most parts where the ridge is very prominent, its south-eastern or seaward edge is more regular and better defined than the landward edge.

Alluvial Flats.—The Carrum Swamp, between Wells'-road and the coastal ridges, has already been described (Hills, 1940B). Although part of it is now permanently under water near Seaford, the general level of the surface, before sinking took place on cultivation, has been stated to have been 4½ feet above sea level.

The Dandenong Swamp is higher than Carrum Swamp, but just as flat. All the water entering the area from the Dandenong and Eumemmerring Creeks is now confined to drains, and the area is no longer swampy. The two most important drains are the Main Drain, which supplies Mordialloc Creek, and a secondary drain which enters the sea through an artificial cut in the coastal sand ridges at Carrum.

Sand ridges form the boundaries of Dandenong Swamp in the north and the south-east (fig. 2), but towards the north-east, the land gradually rises to where Tertiary rocks outcrop at the surface in the neighbourhood of Lyndhurst. The country here becomes undulating, and the Tertiary rocks are in places covered by wind-blown sand.

The south-eastern boundary of the alluvial flats runs approximately north-east from Frankston along the main Frankston-Dandenong road as far as Carrum Downs, and then continues east towards Cranbourne. Thus, for part of the way, it follows

a north-easterly extension of Selwyn's Fault (Hills, 1940A, p. 160). Along the edge of the swamp, the sand hills are very low and irregular, but they increase in height fairly rapidly away from the alluvial flats, not so much because of increasing height

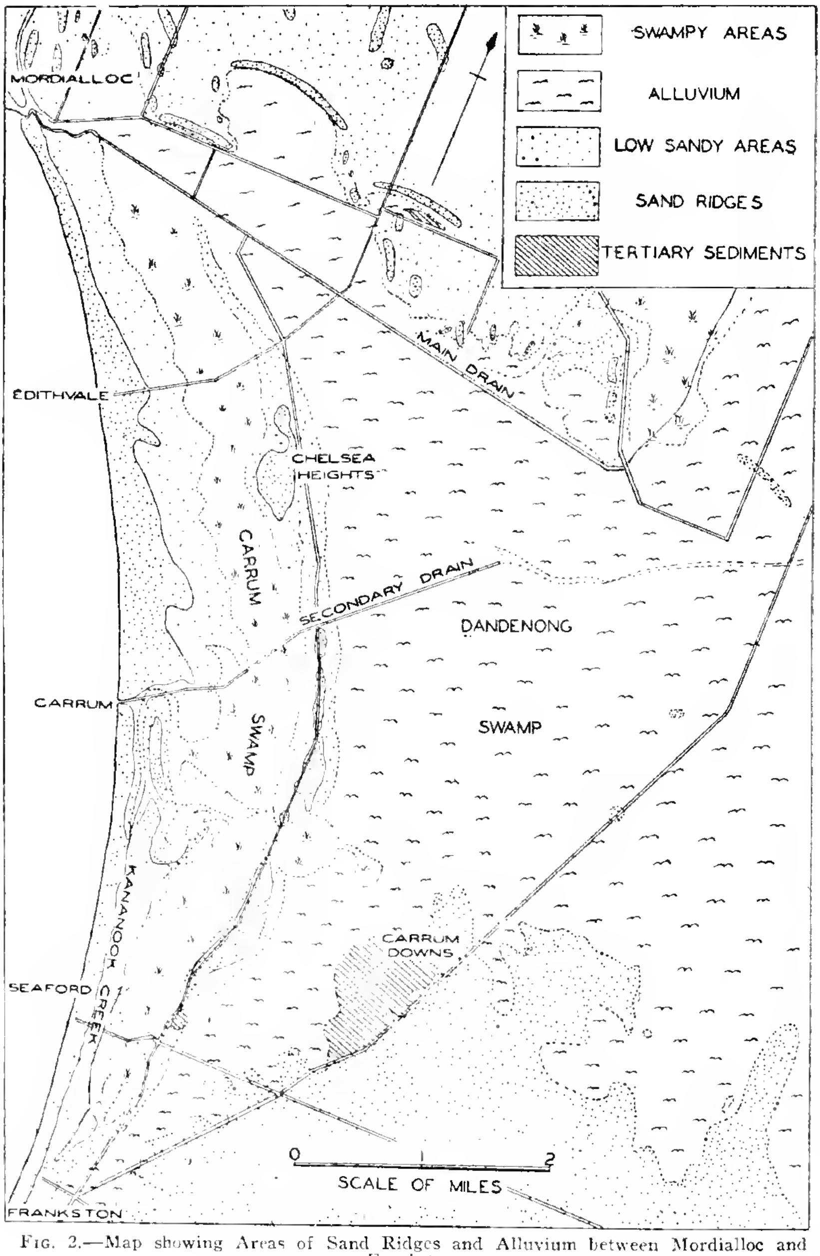

FIG. 2.—Map showing Areas of Sand Ridges and Alluvium between Mordialloc and Frankston.

of sand, but because of the increasing height of the underlying surface of Tertiary and Silurian rocks, which are exposed in many parts of the Frankston district.

Along the northern boundary of Dandenong Swamp, just east of Mordialloc, there are two types of boundary ridges. On the northern side of the Main Drain and east of Edithvale-road are low, irregular, sand ridges, many of which are entirely surrounded by alluvium, and which are probably related to the less regular sand dunes of the north-western sector. The relationship between these sand ridges and the alluvium can be seen in a pit in a low sand ridge near the Edithvale-road. This pit has been continued to a depth level with the surface of the surrounding alluvium, and no change in the nature of the sand can be seen. Below this depth the sand is continuous, indicating that the sand ridge has been partly buried around its base by alluvium. Unlike the south-eastern boundary of the alluvial flats, where the land rises fairly suddenly, the land behind these boundary ridges near the Main Drain rises only gradually towards the north and north-west.

The other ridges along this boundary of the swamp can be seen on the map (fig. 2) mainly between Mordialloc and Edithvale-road, and do not seem to be related to any of the sand ridges already described. They are of uniform height for practically the whole of their length. They trend almost due east and west, are slightly curved with the concave side facing south, and are much longer than any of the other ridges in this part of the area (see fig. 2). The most prominent of these ridges can be seen in a section along the Edithvale-road, just north of Governor-road. The width here is approximately 2 chains and the height approximately 10 feet above the alluvial flats. On the northern side, the land is higher and undulating, with Tertiary rocks outcropping at the surface, which is covered in places by the irregular sand ridges referred to in the North-Western Sector. To the east of these three ridges and on the other side of the Dandenong Creek, there is another relatively long ridge, which is similar in form to those just described, but which could not be closely investigated owing to the fact that it is in a proclaimed military area. As far as could be seen from the road which crosses this ridge, it continues for some distance in an ESE. direction (fig. 2), and both to the north and south of it the land is very flat.

The origin of these ridges is not clear. In their length, uniform height and curvature, they resemble the coastal ridges, and from a consideration of their position it might be suggested that they are remnants of yet another coastline behind Wells'-road. There

is, however, no evidence to show that the coastline has been further inland than Wells'-road since the elevation of the marine Tertiaries. The south-eastern and part of the northern boundary between alluvial flats and the higher sand ridge areas, along whieh one would expect to find evidence of such a coastline, is very irregular and follows the base of the sand ridges as can be seen from the map (fig. 2). Also, the unbroken uniform height of each of these three sand ridges suggests that they have not been greatly altered by erosion and are probably younger than Wells'-road ridge. It is therefore improbable that they were formed along a former coastline.

On the other hand, these sand ridges cannot be classed with the longitudinal dune ridges further east because of their different orientation and their curvature, nor with the barchan dunes because of their uniform height and greater length in relation to width. A possible explanation of their formation is that they have been built up on the northern sides of the swamps in much the same way as the lunettes described by Hills (1939). An important difference, however, is that, whereas the lunettes in northern Victoria are composed of fine dust particles, which is the only material available in the areas where they are formed, the ridges marginal to the Dandenong Swamp are composed almost entirely of sand, probably derived from the sand ridges further south, and from the sandy alluvium of the swampy areas.

With the exception of parts of the Frankston and Cranbourne areas, where older rocks occur, most of the area dealt with in this paper is underlain by arenaceous or argillaceous Tertiary sediments.

Lithology.

In order to determine any significant variations in the lithology of sands deposited under different conditions, the following properties of the sand from each type of deposit were investigated.

Mechanical Composition.—The degree of sorting of the sand was studied by passing the sample through a series of wire mesh sieves, the size of each mesh being half that of the one above it. The sizes used were: $\frac{1}{8}$ mm., $\frac{1}{4}$ mm., $\frac{1}{2}$ mm., and 1 mm., and, where necessary, 2 mm. and 4 mm. The percentage weights remaining on each sieve and in the pan were then calculated, and the results of all mechanical analyses compared by means of histograms (fig. 3).

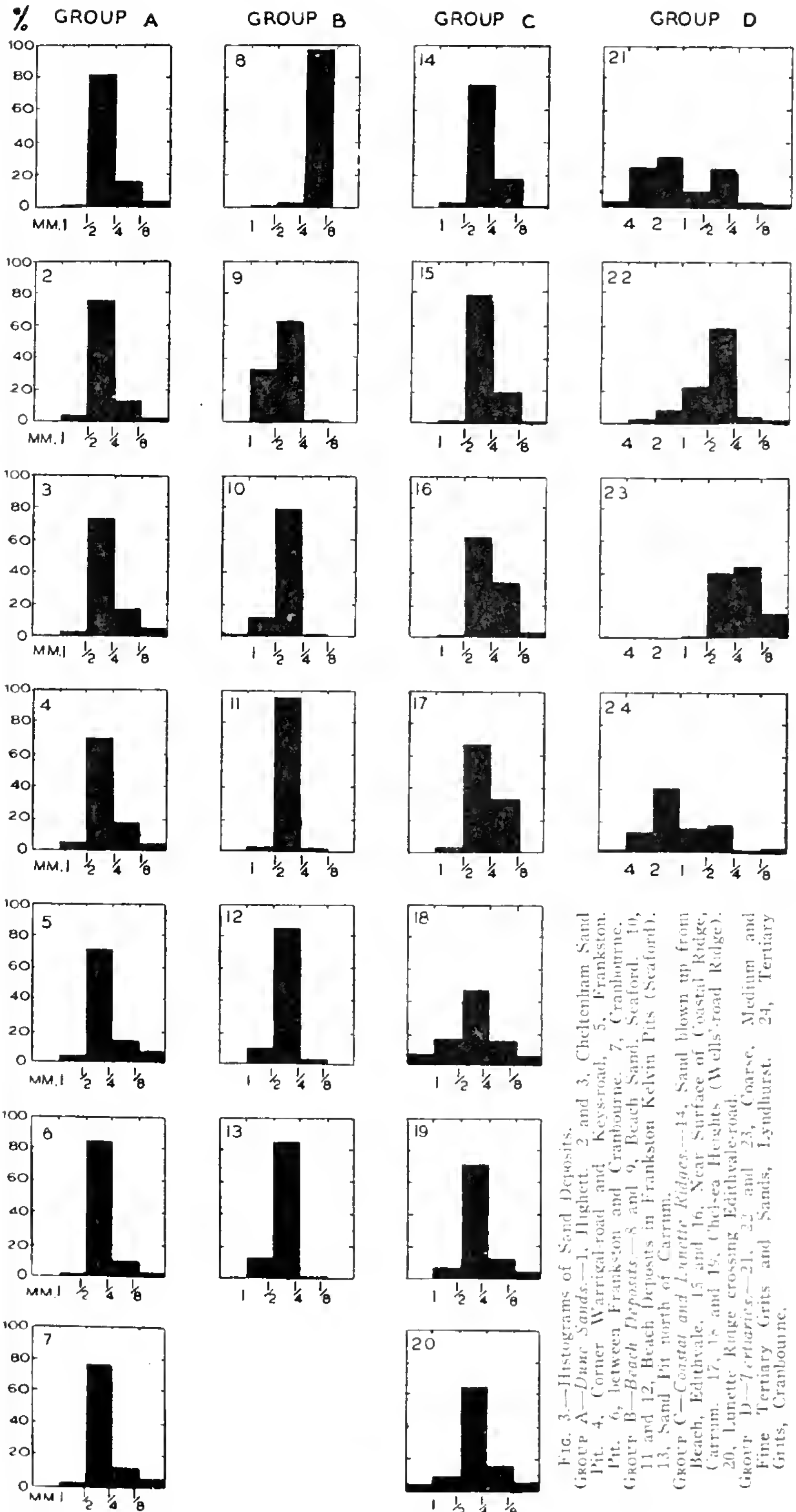

FIG. 3.—Histograms of Sand Deposits.
GROUP A—*Dune Sands.*—1, Highett. 2 and 3, Cheltenham Sand Pit. 4, Corner Warrigal-road and Keys-road, 5, Frankston. Pit. 6, between Frankston and Cranbourne. 7, Cranbourne.
GROUP B—*Beach Deposits.*—8 and 9, Beach Sand, Seaford. 10, 11 and 12, Beach Deposits in Frankston Kelvin Pits (Seaford). 13, Sand Pit north of Carrum.
GROUP C—*Coastal and Lunette Ridges.*—14, Sand blown up from Beach, Edithvale. 15 and 16, Near Surface of Coastal Ridge, Carrum. 17, 18 and 19, Chelsea Heights (Wells'-road Ridge). 20, Lunette Ridge crossing Edithvale-road.
GROUP D—*Tertiaries.*—21, 22 and 23, Coarse, Medium and Fine Tertiary Grits and Sands, Lyndhurst. 24, Tertiary Grits, Cranbourne.

When sampling sand, particularly that of beach deposits, for mechanical analysis, it was found necessary to ensure that all the sand was obtained from the one lamina or bed, as frequently two successive laminae are composed of grains of a different size, this depending largely on the conditions prevailing at the time of their deposition. Although each individual lamina may be well sorted, this fact may be obscured if they are not kept separate.

This precaution was not found to be necessary for dune sands, but in these, as in all the sand deposits, if the sand is to be obtained in the same condition as it was deposited, it must be taken from at least 2 or 3 feet below the surface. This is necessary because the surface sand of the A soil horizon has been leached, being now a pale-grey in colour and containing small amounts of humus. Below this horizon, there is generally a narrow zone of dark-brown sand, partly cemented, and below this again the original sand which is usually slightly iron-stained. The depth to which weathering and soil formation have taken place in sand varies from place to place, being greater on flatter areas such as that just north of Carrum, than on steeper and better-drained slopes as on the sides of the Frankston sand ridges.

Roundness of Grains.—Sand from each grade of the mechanical analysis was examined in reflected light under a binocular microscope, and the degree of rounding of the grains was noted. No quantitative analysis of the roundness of grains was undertaken as it was not felt that such a detailed study would serve any useful purpose in this investigation.

Heavy Minerals.—The heavy mineral assemblages obtained from all sand deposits, as well as from alluvium and Tertiary sediments, were examined and compared (see table of heavy minerals). Separation of the minerals was carried out in bromoform, and for clean sand no preliminary treatment was required. In dealing with samples of material such as alluvium or Tertiary sediments which contain varying amounts of clay, this had first to be removed by washing before a separation in bromoform could be obtained.

Stratification.—Because of the loose, unconsolidated nature of many of the sand deposits, stratification, if present, could not always be seen on a fresh surface unless there was some marked change in the sand in succeeding laminae. Normal dune bedding can be seen, however, on the sides of many of the sand pits which have been exposed to weathering for some time.

Table of Heavy Mineral Assemblages.

	No.	Locality	Andalusite	Augite	Biotite	Brookite	Epidote	Hornblende	Ilmenite	Limonite	Leucoxene	Magnetite	Pyrite	Rutile	Tourmaline	Zircon
Alluvium	1	Carrum Swamp	C		a		r		A	a	r				C	o
	2	Carrum Swamp	r						a	r	r	a	V	C	C	C
	3	Carrum Swamp	r						A			C		C	a	C
	4	Main Drain	V	V	A			a	a	C		C			o	C
	5	Main Drain	r		A			a	r	C		C			r	r
	6	Beach Sand	o		r	V			a	C	r	V		r	a	C
	7	Lunette Ridge	V						a	r		r		r	C	C
Coastal Ridges	8	Seaford	C						C	C		A		r	r	r
	9	Carrum	r		C				a		r	r			C	o
	10	Chelsea Heights	o			V		V	A	o	r			C	C	a
	11	Chelsea Heights	r		V	V	r		a	r	r		V	o	C	C
Dune Sand	12	Highett	r			V			A	r	r	r		o	C	C
	13	Highett	r			V			A		C			C	C	a
	14	Cheltenham	V			r			A		r	a		C	C	a
	15	Cheltenham	o						A			C		o	C	C
	16	Cranbourne	r			V		V	A	C	r	C		C	C	C
	17	Frankston	o			V			A	r	r	C		r	a	a
	18	Between Frankston and Cranbourne	r						A	C	r	V		r	C	o
Tertiary Sands & Grits	19	Lyndhurst (Medium)	V			r			A			V		o	o	o
	20	Lyndhurst (Fine)	r			r			A		r	r		r	o	A
	21	Cranbourne	o				r		A		V	r		o	C	A
	22	Warragul Road					r		A					r	o	o

A - very abundant. C - common r - rare.
a - abundant o - occasional. V - very rare.

Lithological Descriptions.

Sand Ridges of the North-Western and South-Eastern Sectors.

On comparing histograms of sand collected from many of the pits in the Cheltenham and Moorabbin districts, and also from between Frankston and Cranbourne, it was found that the results were remarkably consistent. These sands are very well sorted (see histograms 1-7). In all samples, over 60 per cent. and in most cases over 70 per cent. of the whole fell into one grade ($\frac{1}{4}$-$\frac{1}{2}$ mm.), this grade being the "chief ingredient" as defined by Udden (1914). Of the remainder, the percentage of the sample with grains smaller than those of the chief ingredient, i.e., Udden's "finer admixtures," was always found to be greater than that of grains coarser than the chief ingredient. It seems to be generally accepted that sands which have a consistently small range in grain size and a high degree of sorting are found only in aeolian dunes and in beach deposits, but the uniform size of the chief ingredient of the sand ($\frac{1}{4}$-$\frac{1}{2}$ mm.) throughout all these deposits in Cheltenham and Frankston districts is typical only of dune sand (Retgers, 1895). Although each sample of beach sand is well sorted, the predominating grain size varies from one lamina to the next.

On examining sand from each grade in reflected light, it was found that the proportion of rounded and sub-rounded grains present increases with increasing size, most grains greater than 1 mm. diameter being rounded. This rounding refers only to the quartz grains, which constitute over 99 per cent. of the sand in all the samples examined. The small percentage of heavy minerals, which are nearly restricted to the smallest grade ($< \frac{1}{8}$ mm. diameter), are mostly well rounded, with a few prismatic and angular grains, although all the quartz grains of similar size are angular.

Heavy Minerals.—In all sands collected from the pits referred to above, the most abundant heavy minerals are ilmenite, zircon (round and prismatic), tourmaline (rounded and angular), and rutile. Less common are magnetite, andalusite, limonite and leucoxene (associated with ilmenite). Brookite, hornblende and epidote were recorded from some samples, but not more than one or two grains per slide. In the samples in which these last-named minerals were not recorded, it does not necessarily mean that they are absent from that particular deposit, since it is possible that if it had been practicable to obtain a larger representative sample from that locality, these minerals although rare, would have been recorded.

Stratification.—Typical dune bedding with narrow, closely spaced laminae is present in both the longitudinal and barchan sand ridges, and can be seen on weathered surfaces of many of the sand pits. The direction and angle of dip are variable and cross-bedding is common. In all these deposits the grain size is fairly uniform over a considerable vertical range, i.e., there is no change in grain size from one lamina to the next, and consequently stratification cannot usually be detected on a fresh surface. In addition to this stratification, a peculiar type of horizontal bedding can be seen in the upper parts of nearly all sand pits in the longitudinal ridges of the Cheltenham district, and along Warrigal-road. At regular intervals, usually about 3 in. to 5 in., narrow bands of relatively hard sand, approximately 2-3 mm. thick, project out slightly from the side of the pit. The sand in these bands is more iron-stained than the average, and also contains small amounts of clay. It is possible that the hard bands represent successive surface layers, in which the cementing material was deposited before additions of sand were made during the growth of the ridges. The iron-stained clay may have been deposited as red dust during dust storms and accompanying mud rains similar to, but more severe than, those which sometimes occur over the area in summer at the present time.

Coastal Ridges.

The existence of extensive sand pits near Seaford and Carrum made it possible for these deposits to be closely investigated, and from this investigation it has been concluded that the ridges are composed of wind-blown sand and rest on beach deposits which are exposed in the lower parts of the sand pits.

Beach Deposits Underlying the Ridges.—The most striking feature of these deposits in contrast to the aeolian sand ridges, is the presence in them of a large number of waterworn pebbles and many marine shells. The pebbles consist mainly of limonite or ferruginous grits derived from the Tertiary rocks, and of metamorphosed sandstone similar to that in the metamorphic aureole of the Mt. Eliza granite. Several rounded fragments of silicified wood comparable with that which occur beneath the Older Basalt at Oliver's Hill, Frankston, were also found.

A shell bed identical in type with those on the present beach is exposed in the sand pit near Seaford about ¼ mile from the sea. The bed, which is about 2 inches thick and 1-2 feet wide, consists almost entirely of entire and broken valves of *Amphidesma* mixed with very coarse, well-sorted sand and abundant flakes of biotite. It extends for about 10 yards in a line parallel to the present coastline. Practically all the shells lie with their convex surfaces

uppermost, and it is therefore probable that they were deposited below high-water level. The height of this shell bed above a similar one formed just below high-tide mark on the beach was found to be $3\frac{1}{2}$ feet.

These beach deposits are stratified, and alternate laminae of fine and coarse sand can be seen in many sections through the ridges, particularly along the side of the drain at Carrum, and in the lower 1-2 feet of the shallow pit just north of Carrum, where the sand laminae dip consistently W.S.W. (towards the coastline) at approximately 2°-4°. This pit is not actually in the main sand ridge but in the lower sandy area behind the ridge, and the surface sand is being removed and roughly separated into coarser and finer grades, which are used for building sand and glass making, respectively.

The mechanical composition of sand from some of these laminae is shown in fig. 3, Histograms Nos. 10-13. Neglecting the numerous pebbles present in many samples, the sand was found to be very well sorted with over 80 per cent. in the chief ingredient in most samples. It thus resembles dune sand in the high degree of sorting and the small range in grain size, but there is no record of pebbles ever being found scattered throughout dune sands, and none have been found in the Brighton and Frankston dunes. Another point of difference is that, although the sand from these beach deposits is well sorted, it is not uniform in grain size from bed to bed, that is, instead of the highest percentage of the sample always being found in the grade $\frac{1}{2}$-$\frac{1}{4}$ mm. as in the Cheltenham-Frankston dune sands, the predominating grain size varies in different laminae. For example, in the sand found associated with the shell bed described above, the grade 1-2 mm. forms the chief ingredient, whereas just above this bed the predominating grain size is between $\frac{1}{2}$ and $\frac{1}{4}$ mm.

On examining the histograms of these sands, it can be seen that in most of the samples the percentage of sand coarser than the chief ingredient is slightly higher than that finer than the chief ingredient, and the almost complete absence of grains $< \frac{1}{8}$ mm. in diameter seems to be characteristic. A similar result was obtained for sand collected from the surface of the beach exposed by the retreating tide (Histograms Nos. 8 and 9). Further investigation of sands on the present beach between Mordialloc and Frankston showed that laminae composed of fine sand are, in general, better sorted than those composed of coarse sand, and that very fine or coarse laminae are not as common as those composed of grains between $\frac{1}{4}$ and $\frac{1}{2}$ mm. in diameter. On the beach, the high degree of sorting of the sand can be observed only where the surface has not been disturbed in any way.

The heavy minerals found to be abundant or common in the dune sands are also present in the beach deposits (table of heavy minerals, Nos. 6, 8 and 9). In addition, biotite, which has not been recorded for any of the dune sands other than the coastal dunes, is present in many of the samples from the beach deposits in the sand pits, and from the present beach where it is particularly common at low tide mark. In the light minerals, although quartz is by far the most abundant mineral, shell fragments are also common in sand from the beach, and present, but rare, in sand from the pits.

The Ridges.—In contrast with the beach deposits underlying them, the sand forming the coastal ridges is unstratified and contains no shells or pebbles.

In mechanical composition, this sand is similar to dune sand in that the grade $\frac{1}{4}$-$\frac{1}{2}$ mm. is always the chief ingredient and the percentage of finer admixtures is greater than the percentage of coarser admixtures. The degree of sorting, however, varies and, in some samples taken from near the top of the ridge near Carrum, there is a high percentage of grains in both the $\frac{1}{4}$-$\frac{1}{2}$ mm. and $\frac{1}{8}$-$\frac{1}{4}$ mm. grades (Histogram No. 17). This might be expected if the sand forming the ridges had been blown up from the beach in the immediate vicinity, where laminae composed of grains of varying sizes were present. In travelling over such a short distance, there would be little chance of any sorting of the grains.

The heavy minerals found in this wind-blown sand are the same as those found on the beach sand, but biotite, although present, is not as common as in the beach deposits.

Shell fragments also occur but, like biotite, they are not nearly as abundant as on the beach.

Wells'-road Ridge.—The mechanical composition of sand from near the surface of this ridge varies from place to place. Some of it is not very well sorted (Histogram No. 18). Some resembles dune sand (Histogram No. 19), and some is similar in composition to the sand near the surface of the coastal dune ridge near Carrum (Histogram No. 17).

In the heavy mineral assemblages, biotite, although very rare, has been found in one sample from Chelsea Heights, but not in the others. As well as the common minerals (ilmenite, zircon, tourmaline, rutile, andalusite), brookite, epidote and hornblende have also been identified in these samples; shell fragments and pebbles are absent.

Considering the absence of shells and pebbles, it seems probable that the ridge is composed entirely of wind-blown sand, and was built up just behind a former coastline, from sand blown up from the beach, which was then situated along the south-east side of the ridge.

Alluvium.—The surface soil of both Carrum and Dandenong Swamps is sandy, but contains a fair amount of organic matter and is, therefore, dark in colour. In Carrum Swamp, this surface layer is underlain by sand containing marine fossils, the most common of which is *Arca trapezia.* Behind Wells'-road, no shell layer could be found, although numerous channels were examined. This is in agreement with the supposition that, whereas the Carrum Swamp area has recently been covered by the sea, Dandenong Swamp has not.

Heavy minerals present in alluvium from Carrum Swamp and in silt and sand brought down by Dandenong Creek and deposited in the Main Drain include ilmenite, zircon, tourmaline and andalusite in all samples. Rutile and biotite were also present in some samples from Carrum Swamp. In the alluvium deposited in the Main Drain, the most noticeable feature is the abundance of biotite and hornblende (see table of heavy minerals, Nos. 4 and 5).

Lunette Ridges.—The depth of sand in these ridges is not very great, and in a section which has been cut through one of them, where it crosses Edithvale-road, the sand can be seen resting on a layer of clay and pebbles of limonite, which in turn rests on consolidated Tertiary grits at the same elevation as those exposed at the surface to the north of the ridge.

From what could be seen of the sand forming this ridge, it is unstratified as in typical lunettes. Mechanical analysis showed it to be less well sorted than normal dune sands as it contains several larger grains as well as some clay.

The heavy minerals present are the same as those found in the dune sands.

Tertiary Sediments.—Over the whole of the area from Brighton to Frankston, Tertiary rocks are exposed at the surface, or are present at no great depth beneath the sand and alluvial deposits.

West of the Cheltenham axis, these rocks outcrop along all the valley floors and are exposed beneath the sand in pits and sections through many of the ridges. They vary from pale-coloured clays found along the lower parts of Elsternwick Creek to ferruginous sandstones found towards Cheltenham and Mordialloc. Beneath the sand ridges, the Tertiary rocks are generally found at a higher

level than in the adjacent valleys, and consist mainly of loose and partly consolidated grits and sands, in some places very similar to the overlying dune sand except for the large percentage of clay present. These sediments can be seen in sections along the Frankston and Sandringham railway lines, and also in sand pits along Warrigal-road.

On the eastern side of the Cheltenham axis, the Tertiary rocks exposed differ from those described above chiefly in the absence of clays and the presence of unconsolidated grits and abundant limonite concretions.

In the Lyndhurst gravel pit, which is approximately 9 miles north-east of Frankston and 4 miles south-east of Dandenong, very fine unconsolidated sand, in which the grains are all $< \frac{1}{2}$ mm. in size (see Histogram No. 23), is exposed at the bottom of the pit. It is not as well sorted as dune sand and contains a small amount of clay. Horizontal bedding can be seen where the sand has been partly cemented by limonite. Above this fine sand and apparently conformable with it are coarse sands mixed with larger quartz pebbles and clay, all of which are stained intensely red by limonite. Higher up, these sands pass into coarse grits and gravels.

The deposits are roughly stratified, and cross bedding is very common, but there appears to be no consistent direction of dip of the current-bedded layers. The most striking feature of most of these deposits is their intense red colour, due to limonite staining.

Very hard ferruginous grits outcrop approximately 3 miles east of Mordialloc between the main lunette ridge described above and the low sand dunes to the south of it (fig. 2). Over the rest of the Dandenong Swamp, no Tertiary rocks are found at the surface, but where bores or deep channels have been made, ferruginous grits and fine sands have been brought to the surface.

The grits again outcrop near the south-eastern boundary of Dandenong Swamp in the neighbourhood of Carrum Downs, and in this locality concretionary forms of limonite are common on the surface. Material brought up from a well situated about $\frac{1}{4}$ mile from the main Frankston-Dandenong road was found to consist almost entirely of fine white sand similar to that underlying the grits at Lyndhurst and Cranbourne, but without the limonite staining. Grits similar to those at Lyndhurst also outcrop at one point along Wells'-road, just north of Carrum Vale-road (fig. 2).

Results of mechanical analyses of sands and gravels from Lyndhurst and Cranbourne (Histograms Nos. 21-24) show that the coarser material has been very poorly sorted and this, combined with the irregular current bedding, suggests that these sediments have been deposited very rapidly, probably from rivers, and may perhaps be piedmont deposits.

Heavy minerals present in these grits include ilmenite, magnetite, zircon, tourmaline, rutile and andalusite. Rare grains of brookite were recorded in samples from Lyndhurst, and rare epidote from Cranbourne and also a pit on Warrigal-road. The various types of zircon—rounded, prismatic and stumpy—and also the different varieties of tourmaline, ranging from bluish-grey to pink and brown, are similar to the zircon and tourmaline grains present in the overlying sand deposits. Thus, all the heavy minerals found in the Tertiary deposits are also found in the sand ridges and beach deposits, with the addition of biotite in the beach deposits, and biotite and hornblende in the alluvium brought down by the Dandenong Creek.

In the Frankston area, Tertiary grits are exposed in many sections along the Frankston-Cranbourne road. These grits are similar to those found further north and west, but, in addition, they contain abundant large and well-formed flakes of kaolinite. Because of the size of these kaolinite "books," it is probable that the mineral has been formed after the deposition of the grits, in which it occurs, by alteration of felspars originally present.

Where the passage from Tertiary rocks to dune sand is exposed near one of the old Frankston sand pits near the Stony Point railway line, the dune sand can be seen resting on a layer of well-rounded and closely packed pebbles of Tertiary grits, approximately 1 inch in diameter. Below this is normal Tertiary rock. These pebbles may represent "lag gravels" left by the wind prior to the accumulation of sand forming the dunes. A similar layer of rounded pebbles was found overlying the Tertiaries near the corner of North-road and Boundary-road. Although this locality is just outside the area covered by the sand ridges, the gravels are overlain by approximately 3 feet of wind-blown sand drift. In all other sections where the passage from Tertiary rock to dune sand is exposed, no such gravels were found, and their local occurrence probably depends on the nature of the Tertiary sediments at that particular place.

Summary of Lithology.

MECHANICAL COMPOSITION.

As can be seen from the histograms, dune and beach sands can be distinguished from other sediments by the small range in grain size and by the high degree of sorting. However, for differentiating between these two types of sands, a mechanical analysis does not prove very satisfactory if the sand alone is analysed and the presence or absence of pebbles ignored. Three small points of difference have been observed, and the most striking of these is the size of the chief ingredient, i.e., the predominating grain size. As has been pointed out above, in all the dune sands examined, the predominating grain size is between $\frac{1}{2}$ and $\frac{1}{4}$ mm., but in the beach sands it varies from place to place. In one sample, most of the grains are between 1 and $\frac{1}{2}$ mm. in diameter, whereas in another they are between $\frac{1}{4}$ and $\frac{1}{8}$ mm. Secondly, in the dune sand, the percentage of finer admixtures was found to be higher than that of the coarser admixtures, whereas in beach sands the reverse was found to be true. Thirdly, there is an almost complete absence of grains less than $\frac{1}{8}$ mm. in diameter from the beach sands.

As can be seen from the histograms, the range in grain size in the Upper Tertiary sediments is much greater than in the superficial sand deposits, and the degree of sorting is much less. Coarse grit, sands, and clay have apparently all been deposited simultaneously in the one spot, and this, together with the irregular current bedding, seems to exclude the possibility of their having been deposited under marine, esturine, or lacustrine conditions, and, as suggested above, they are probably fluviatile in origin.

Roundness of Grains.—In all the superficial sand deposits, the roundness of grains decreases with decreasing size. This is also true for the smaller grades in the Tertiary sediments, but in these, the larger grains ($>$ 2 mm. in diameter) instead of being more rounded, are more angular than the coarse sand fraction.

As far as could be judged by estimation alone, without any quantitative analysis of degree of rounding, there is no difference between the rounding of grains in beach sand and those in dune sands. In all the samples examined, there appears to be a mixture of very well rounded and angular grains. It does not seem probable that the large number of angular grains present, even in the coarsest grades of dune and beach sand, could be due to recent fracture of older grains, so that it may be suggested that the sand has been derived both from older sedimentary rocks and directly from igneous rocks. It would, therefore, be very difficult to determine the relative amounts of rounding due to wave action along the beach and to wind action during the formation of the

dunes, but, because of the short distance over which the dune sand has been transported by the wind, rounding due to this agency was probably very slight. It has been stated by Anderson (1926) that water is more effective in rounding grains than is wind, and that the beach presents the ideal situation for the rounding of sand grains.

Stratification.—As has been pointed out above, the fundamental difference in stratification of dune and beach sands is the uniform grain size of the former, and the variation from one lamina to the next in the latter. Current bedding is common in both types of deposit, and, although the angle of dip of the narrow laminae is variable, it is generally much less in the beach deposits than in the dune sands.

The regular horizontal bedding exposed in the Cheltenham, Warrigal-road and Clayton-road pits described above seems to be peculiar to the upper parts of the longitudinal dunes inasmuch as it has not been observed in any of the pits in the sandhills in the Frankston district.

Heavy Minerals.—The heavy minerals occurring abundantly in the dune sands, beach deposits and dune ridges, namely, ilmenite, zircon, tourmaline, and rutile, and, less commonly, magnetite, andalusite, and leucoxene, are similar to those found in the Tertiary sediments. Brookite, which is rare in all the sand deposits, is also present in the Tertiaries. Limonite, which is present in most of the samples from the recent sand formations, is absent from the Tertiary rocks as actual grains, although it is present as cementing material and in the form of concretions.

Of the minerals not found in all the sands, biotite appears to be the only one of any significance in relation to the origin of the deposits. It is common in sand on the beach, in the old beach deposits beneath the coastal ridge, in the alluvium from Carrum Swamp, and in material from the Main Drain in the Dandenong Swamp. On the other hand, it was not identified in any of the dune sands. This is in agreement with the findings of Retgers (1895), who suggested that, because of its form, biotite is seldom found in wind-blown sands. Its presence in the wind-blown sand forming the tops of the coastal ridges, however, is to be expected in view of the very short distance travelled by the sand from the beach, where biotite was abundant. Even so, the amount of biotite present in the blown sand is noticeably less than on the beach.

In conclusion, the abundance of well-rounded grains of ilmenite, tourmaline and rutile in all the sand deposits suggests that the sand has been derived largely from the pre-existing sedimentary rocks, since for these minerals to become rounded several cycles of erosion are usually necessary (Hatch, Rastall and Black, p. 92). As these minerals are similar to those occurring in the

Tertiary sediments, many of which are unconsolidated, it is probable that much of the sand now forming the inland dunes has been derived from these sediments. Any sand derived from igneous rocks as indicated by the angular condition of the grains, may have come by way of the beach from local granite outcrops near Frankston or from sand carried down from the Eastern Highlands by the rivers.

Physiographic Evolution of Area.

All the sand dunes dealt with are now fixed by vegetation, and there is practically no movement of sand over the area excepting in the coastal ridges. The inland dunes must have been built up, therefore, at some time when there was no protective covering of vegetation, and any sand on the surface was free to be blown about by the wind. To account for these conditions, a much drier climate than that of the present day is necessary.

As has been pointed out above, longitudinal dunes having a north-westerly trend were formed in the Brighton area, and irregular barchan dunes in the Frankston area. As it seems to be generally accepted (Madigan, 1936; Hack, 1941; Bagnold, 1941) that longitudinal dunes are formed parallel to the prevailing wind, it is probable that the Brighton ridges owe their formation to either north-westerly or south-easterly winds. South-easterly winds would probably have brought rain, and it is therefore suggested that strong north-westerly winds blowing from the interior of the continent caused the formation of the longitudinal dunes over the sandy coastal plain.

The reason for the difference in form of the sand ridges in the north-west and south-east parts of the area is probably due to differences in the original topography, and in the sand supply. The origin of various types of dunes has been investigated by Hack (1941), who suggested that longitudinal dunes are developed only over flat areas with a meagre sand supply, whereas barchans require a much greater sand supply for their formation.

A brief investigation of the Tertiary rocks underlying the sand deposits revealed that in the extreme north-west of the area clays and consolidated grits outcrop at the surface; over the Brighton area unconsolidated sands and grits were found only beneath the ridges, and are probably of no great depth. In the central sector, the thickness of the loose sands and grits, judging from the available exposures, is much greater than further north-west. Assuming that the dunes were formed by prevailing north-west winds,

the amount of sand available for their information, therefore, was probably much greater towards the south-eastern part of the area than in the extreme north-west.

The coastal plain of the Brighton district is still relatively flat, except for the ridges and, given the required conditions of wind and sand supply, longitudinal dunes would be formed over this area. In the Frankston district, hills of Silurian rock and outcrops of Tertiary grits now project above many of the sand ridges, indicating that the topography of this part of the area was much more irregular than further north-west, and thus longitudinal dune ridges would not be formed in this district.

The drainage system, which developed in the north-western part of the area after the period of dune formation had been brought to a close by a return to moisture conditions, has been determined by the position of the sand ridges rather than by the general slope of the country, which is towards the south-west, and the streams now occupy the valleys which were formed simultaneously with the sand ridges, and therefore trend north-west. The direction of drainage is reversed along the Cheltenham axis, however, and the streams flow south-east towards Carrum Swamp. The presence of this minor divide is due to structures in the underlying Tertiary rocks. Although they are almost horizontal or dip at very slight angles over most of the area, at Beaumaris Bay the beds dip S.E. at 25° and flatten out again on either side, thus forming a monoclinal fold. The low divide, which has been described by Hart (1913) as the "Notting Hill-Cheltenham axis," follows the strike of this fold from Cheltenham to Mitcham. Since there is no abrupt change in the form of the sand ridges crossing the divide, it is probable that inequalities in level of the surface produced by the folding were almost smoothed out by erosion before the formation of the sand ridges.

Another tectonic feature in the underlying rocks which has helped to determine the present physiography is Selwyn's Fault in the south-eastern part of the area. Relative subsidence of the land between the monoclinal fold and Selwyn's Fault has been the chief factor in determining the position of Carrum and Dandenong Swamps, which, however, are of a much later date than the tectonic movements.

The presence of isolated sand hills projecting slightly above the level of the alluvium of the Dandenong Swamp (fig. 2) indicates that this flat area was also covered by sand dunes at one time, but

these have probably been eroded to a much greater extent than those to the north-west and south-east, because of the concentration of drainage into this relatively low-lying area. This area probably did not become a swamp until after a general rise of sea level caused the flooding of Port Phillip Bay and brought the coastline approximately to the position of the Wells'-road ridge. It is probable that the coastline was at first rather more irregular and for a very short time was a little further inland than this ridge, which may have been formed first as an off-shore bar and later became the coast as the depression behind it was silted up. As the dune ridge was built up along the former shoreline, drainage from the Dandenong and Eumemmering Creeks was impeded, and the water spread out, forming swamps in which most of the sand from the ridges was removed and redistributed, and the remaining sand hills partially or completely buried. The lunette ridges, situated as they now are along the northern boundary of the alluvial flats, were built up on the northern sides of the swamps, suggesting that the dominant wind causing sand movement was at this time from the south or south-west and not from the north-west as during the dry climatic period.

Recession of the coastline from Wells'-road to its present position, with the consequent formation of a younger dune ridge separating Carrum Swamp from the sea, resulted from a recent emergence of the coastline (Hills, 1940B).

The presence of the depression occupied by Kananook Creek indicates that there are at least two dune ridges very close together. This fact, together with the presence of beach deposits and shell beds $3\frac{1}{2}$ feet above high-tide mark, suggests that there has been a more recent emergence of at least $3\frac{1}{2}$ feet, probably a little more. This is in agreement with further evidence given by Hills (1940B) for a recent emergence of the shores of Port Phillip Bay.

Acknowledgments.

The author is indebted to Dr. E. S. Hills for information concerning the area and for advice during preparation of the manuscript, to the Melbourne and Metropolitan Board of Works for the use of aerial photographs and stereoscope, and to Miss H. Macpherson and Miss J. Dickinson for assistance in mapping the Frankston area. The levelling between the shell bed in the coastal ridge and high-tide mark was carried out by Miss H. Macpherson, Miss J. Dickinson, Mr. J. L. Knight and Mr. C. R. Harding under the direction of the author.

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ART. V.—*The Geology of the Port Campbell District.*

By GEORGE BAKER, M.Sc.

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Abstract.

In the coastal cliffs east and west of Port Campbell township, Middle Tertiary calcareous clays and limestones are assigned a (?) Balcombian age, while underlying deposits between Glenample Steps and a locality ¾-mile N.W. of the Gellibrand River are classed with the Balcombian from palaeontological and lithological correlation with beds of that age described from other parts of Victoria. Balcombian and (?) Balcombian sediments outcrop for over 15 miles along the coast, are from 750′-1,000′ thick, and conformably overlie a thin series (60′-100′) of deposits composed of grit, conglomerate, limestone and calcareous clay, probably of Janjukian age. Unfossiliferous beds beneath and conformable with the Janjukian sediments may be Oligocene. The sediments are principally horizontal with occasional gentle undulations and a few small faults. They dip down to form a broad, shallow syncline in the west of the area, and have low westerly dips in the south-east. The Balcombian, Janjukian and (?) Oligocene deposits are apparently conformable with westerly dipping Eocene rocks which occur south-east of the Gellibrand River and unconformably overstep Jurassic rocks. The general indications in the Tertiary beds are that an uninterrupted sequence of deposition occurred from Eocene to Balcombian times, after which this theatre of sedimentation was elevated to form a land mass. Post-Miocene clays form a thin veneer on the Middle Tertiary rocks. Pleistocene dune limestone has infilled the valley of the pre-Pleistocene ancestor of the Gellibrand River. Recent deposits occur along present river courses, at the base of the coastal cliffs in parts of the area and across the mouths of the larger watercourses.

Introduction.

The Port Campbell district is situated on the south-west coast of Victoria. The area investigated constitutes the coastal strip of the southern portion of the county of Heytesbury, and stretches from Peterborough in the west to a point two and a half miles south-east of Princetown (fig. 1).

The oldest Tertiary rocks of the area are exposed in the sea-cliffs at Pebble Point in the south-east. They are grits and sandy ironstones of Eocene age, overlain by fossiliferous clays and sandstones which are also probably Eocene (1, 30, 33). Unfossiliferous ferruginous and carbonaceous sandstones above the Eocene beds may be of Oligocene age. This series of deposits occurs S.E. of the Gellibrand River.

Fossiliferous limestones, argillaceous limestones and calcareous clays of Miocene age outcrop extensively to the west and north-west of the Gellibrand River. They are soft rocks which form

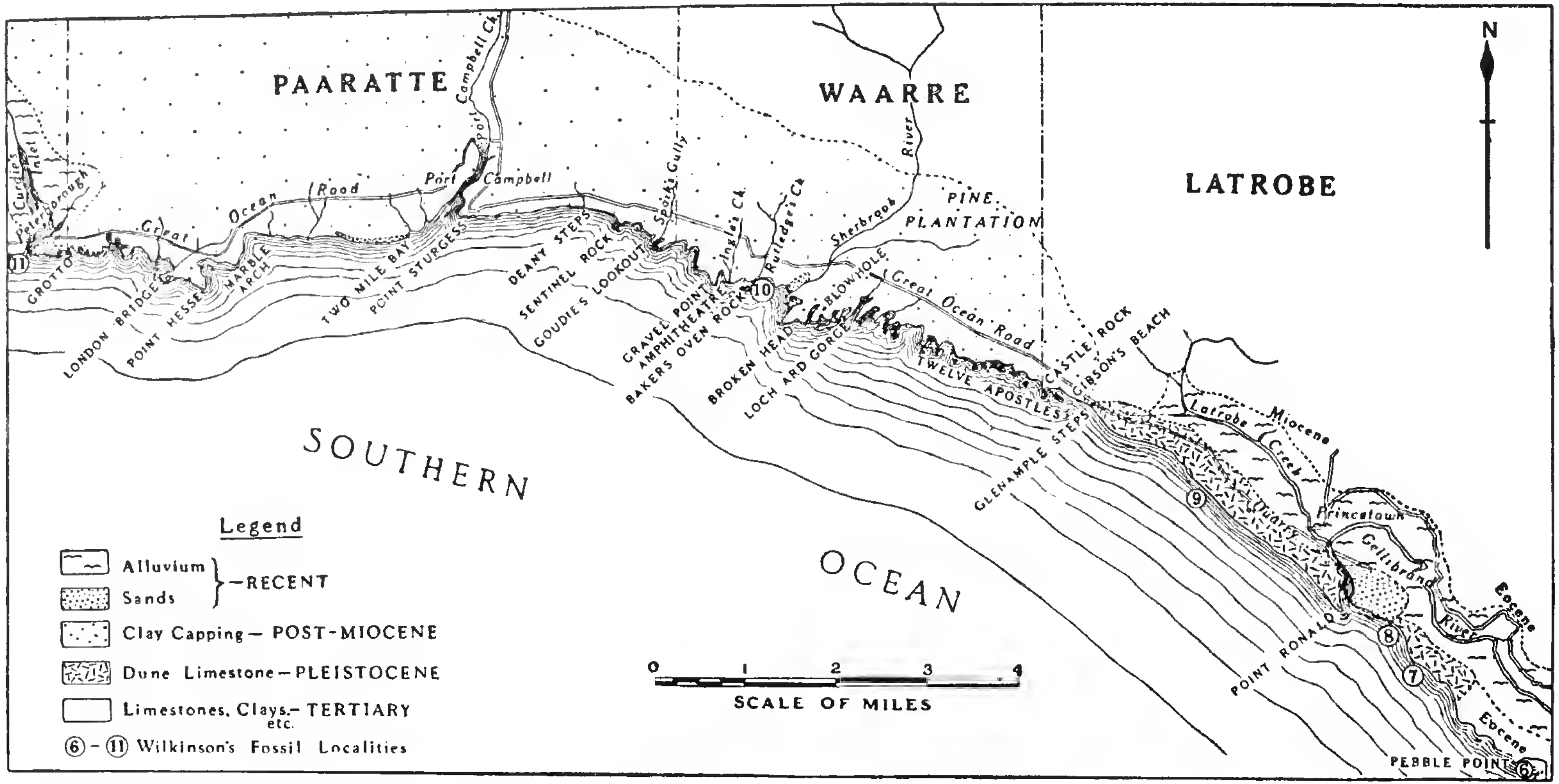

FIG 1.—Geological Sketch Map of the Peterborough–Port Campbell–Princetown Coastal Area, showing place names. Outline compiled from State Parish Plans in the County of Heytesbury.

the high, vertical cliffs so characteristic of the coastline from Glenample Steps (fig. 1) to Peterborough.

The basal members of the Tertiary deposits, i.e., the Eocene beds, rest unconformably, with some overstepping, upon an erosion surface in Jurassic arkoses and mudstones which form widespread outcrops in the Cape Otway Peninsula.

The Miocene beds are classified principally with the Balcombian series from the results of detailed investigations of the foraminiferal content of various members of the deposits by Mr. W. J. Parr (see appendix), and from the preliminary examination of the molluscan fauna by Dr. F. A. Singleton.

A veneer of clays on the Tertiary deposits is regarded as of post-Miocene age. The vertical nature of the cliffs in the district renders many parts of the Tertiary exposures inaccessible. Nevertheless, such portions of the cliffs as could be studied provide considerable evidence of the age sequences in the Tertiary succession. The Tertiary rocks of the coastal sections in the immediate vicinity of Princetown are partially obscured by considerable thicknesses of Pleistocene dune limestone for a distance of approximately 4 miles. This portion of the area represents an infilled valley of the ancestor of the Gellibrand River. Recent, partially fixed calcareous sand dunes have been built up on the consolidated Pleistocene dune limestone in this part of the area, and also on eroded Tertiary rocks at the mouths of the Curdie and Sherbrook Rivers. Behind river-mouth sand dunes and beach sand-ridges along the coast, deposits of sand and alluvium have accumulated, more particularly upon the valley floors of Port Campbell Creek, the Sherbrook and Gellibrand Rivers and Curdie's Inlet. The Recent deposits of the Gellibrand River and of Curdie's Inlet contain shallow-water marine, as well as fluviatile, sediments.

Previous Work.

The area was originally surveyed by C. S. Wilkinson in 1865, when all of the Tertiary rocks in the district were regarded as Lower Miocene in age (34). The accompanying section (fig. 2) was prepared by Mr. A. E. Kennedy, of the Victorian Mines Department, from the original by Wilkinson. It has not been published previously, and portrays, with a considerable degree of accuracy, the general relationships of the Mesozoic, Tertiary and post-Tertiary rocks from Moonlight Head in the south-east, to Warrnambool in the west. This section embraces the Peterborough-Port Campbell-Princetown coastal sections, recent investigations of which show a few minor departures from Wilkinson's original work. The numbers on the section refer to Wilkinson's fossil localities. The vertical scale, not noted by Wilkinson, is approximately $\frac{1}{8}'' = 250$ feet.

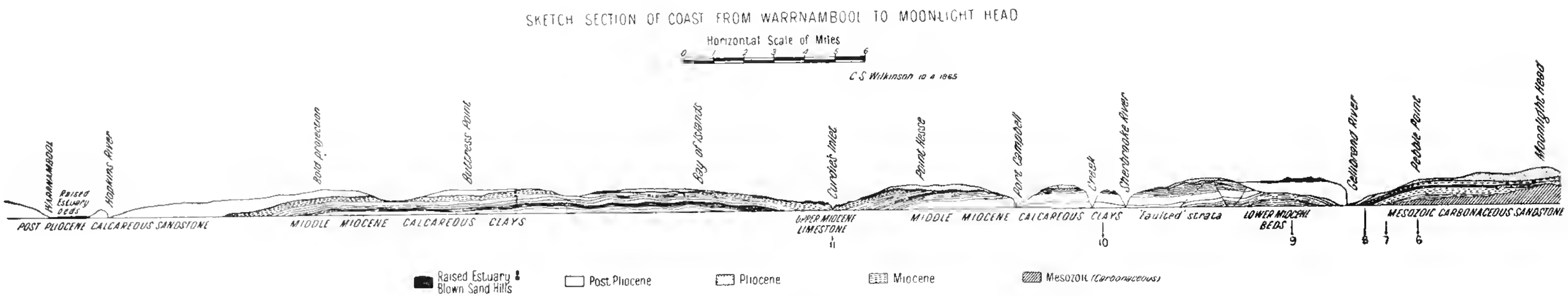

FIG. 2.—Wilkinson's Section from Moonlight Head to Warrnambool.

In 1868, H. M. Jenkins examined fossils collected from the area, and classified the beds immediately N.W. of the mouth of the Gellibrand River as Miocene, stating that the most important bed was a dark, slate-coloured, stiff clay, very rich in fossils and remarkable for yielding perhaps the finest examples of Cypraea which occur in the fossil condition. Jenkins regarded deposits near the Sherbrook River (at a locality now known as the Rutledge's Creek coastal section), from which he recorded *Trigonia lamarcki*, as probably being referable to the same horizon as the Mordialloc deposits in Port Phillip Bay, characterized by the same form of Trigonia, and mapped as Lower Pliocene by the Victorian geological surveyors (19). It is now known, however, that this Trigonia at both these localities is not *Neotrigonia lamarcki*, a recent species from the New South Wales coast, but is *Neotrigonia acuticostata* (McCoy), a closely allied species described from Beaumaris.

In 1870, P. M. Duncan reproduced the results of elaborate surveys made by Victorian geologists, and described the corals collected from the deposits between the Gellibrand River and Moonlight Head (13). Later, he described the echinoids from various portions of the area (14).

In 1877, R. A. F. Murray included additional notes on this area in his report on the Cape Otway district (23), giving details concerning the marshy flats of the Gellibrand River, the dune rock at the mouth of this river, the age relations of some of the Tertiary deposits, and correlations with Tertiary outcrops in other parts of Victoria.

Various ages have been assigned to the Tertiary deposits of the Port Campbell and neighbouring coastal sections from time to time. Tate (31), Tate and Dennant (32), Pritchard (25, 26, 27 and 28), Maplestone (20, 21 and 22), Dennant and Kitson (12), Chapman (2-8), Hall (15, 16), Chapple (9, 10) and Parr and Collins (24) have described various fossils from the several component beds of the Tertiary deposits between Peterborough and Pebble Point. Most of these authors correlated individual fossils or suites of various groups of the invertebrate fossils with those found in other Victorian Tertiary deposits. The results of the correlations have varied as a consequence of changes in opinion concerning the general sequence of the Tertiary succession in Victoria. Recent ideas concerning this succession are set out by Singleton (29, pp. 63-64), and included in his table of correlation are some of the Tertiary deposits of the Port Campbell district.

The various opinions relating to the age of the Port Campbell Tertiary rocks are summarized in Table 1, where localities elsewhere in Victoria, with which certain of the Port Campbell strata have been correlated, are also tabulated.

TABLE 1.

Location of Beds.	Age.	Author.	Date.	Correlated Localities.
Deposits between Gellibrand River and Moonlight Head (= Pebble Point Beds)	Miocene ..	Duncan ..	1870	Beds at Aire River. Castle Cove. Locality 1 mile east of Point Addis
,, ,, ,,	Middle Tertiary (Miocene)	Murray ..	1877	
,, ,, ,,	Upper Eocene	Dennant and Kitson	1903	
,, ,, ,,	Barwonian (Balcombian)	Chapman ..	1904	
,, ,, ,,	Lower Janjukian	Pritchard ..	1923	
,, ,, ,,	Eocene ..	Teichert, Singleton, Baker	1943	
Gellibrand Clays, 3 miles north-west of mouth of Gellibrand River	Lower Miocene	Wilkinson ..	1865	Orphan Asylum Reserve, Fyansford, near Geelong
,, ,, ,,	Miocene ..	Jenkins ..	1868	
,, ,, ,,	Lower Oligocene	McCoy ..	1874–1882	
,, ,, ,,	Eocene ..	Tate and Dennant	1893–1896	
,, ,, ,,	Lower Tertiary (Oligocene)	Murray ..	1877	Point 2 miles west of Cape Otway. East bank of Aire River. Coast between Aire River and Castle Cove. Coast between Mt. Eliza and Mt. Martha
Gellibrand Clays, 3 miles west of mouth of Gellibrand River	Upper Eocene	Tate ..	1899	
,, ,, ,,	Eocene ..	Pritchard ..	1901	
,, ,, ,,	Balcombian (Eocene)	Pritchard ..	1904	
,, ,, ,,	Barwonian (Eocene)	Tate and Dennant	1904	Muddy Creek (lower beds). Mornington.
,, ,, ,,	Janjukian (Miocene)	Chapman and Gabriel	1923	
,, ,, ,,	Janjukian (Miocene)	Chapman and Singleton	1925	
,, ,, ,,	Lower Miocene	Chapman and Crespin	1935	Basal beds at Sherbrook River. Lake Gnotuk and Lake Bullenmerri near Camperdown
,, ,, ,,	Balcombian (Middle Miocene)	Singleton ..	1940	Muddy Creek (lower beds). Mornington. Fyansford. Barwon River. Mitchell River. Lower part of Sorrento bore. Upper beds at Maude. Ironstones at Keilor and Royal Park (lower beds)
Loch Ard Gorge (Lower portion)	Middle Miocene	Chapman and Crespin	1935	Peterborough
Loch Ard Gorge (Upper portion)	Upper Miocene	Chapman and Crespin	1935	Lake Gilleah near Allansford. First and second creeks (Rutledge's and Ingle's) west of Sherbrook River
Sherbrook River ..	Eocene ..	Tate and Dennant	1893–1896	
,, ,,	Barwonian (Eocene)	Hall ..	1907	
,, ,,	Barwonian ..	Chapman ..	1914	European Miocene
Sherbrook River (Basal beds)	Lower Miocene	Chapman and Crespin	1935	Gellibrand River, near Princetown

TABLE 1.—*continued.*

Location of Beds.	Age.	Author.	Date.	Correlated Localities.
Creek 1 mile west of Sherbrook River (= Rutledge's Creek)	Lower Pliocene	Jenkins ..	1868	Mordialloc beds
,, ,, ,,	Middle Miocene	McCoy ..	1874–1882	
,, ,, ,,	Middle Miocene	Murray ..	1877	
,, ,, ,,	Janjukian (Miocene)	Chapman and Gabriel	1923	
,, ,, ,,	Janjukian (Miocene)	Chapman and Singleton	1925	
,, ,, ,,	Upper Miocene	Chapman and Crespin	1935	Lake Gilleah near Allansford
Rutledge's Creek (Upper beds)	Kalimnan (Lower Pliocene)	Chapman and Crespin	1935	Forsyth's (Grange Burn) McDonald's (Muddy Creek), Russell's Creek (Warrnambool). Portland (lower beds).
Rutledge's Creek (Lower beds)	Cheltenhamian (Upper Miocene)	Singleton ..	1940	Upper beds at Beaumaris. (?) Middle part of Sorrento bore
Port Campbell ..	Eocene ..	Tate and Dennant	1893–1896	
Two Mile Bay ..	Barwonian (Eocene)	Hall and Pritchard	1905	Curlewis (Oligocene of McCoy; Miocene of Chapman)
Curdie's Inlet ..	Miocene ..	Parr and Collins	1937	
Calcareous Sandrock, Gellibrand River	Post-Pliocene	Jenkins ..	1868	
,, ,,	Recent (Upper Pliocene)	Murray ..	1877	
Clays above Tertiary Rocks along coast, Port Campbell	Upper Tertiary	Murray ..	1877	

It can be seen from Table 1 that the clays of the Gellibrand River section have been classed by different authors into various stages of the Tertiary System—Eocene (26 and 32), Upper Eocene (31), Lower Oligocene (23), Oligocene (23), Lower Miocene (6), Middle Miocene (29) and Miocene (13, 34), while the beds stratigraphically higher than these clays (i.e., at Loch Ard Gorge, Sherbrook River and environs, &c.) have been variously placed in the Eocene (16), Lower Miocene (6), Middle Miocene (29), Upper Miocene (29) and Lower Pliocene (6). The correlation of the Gellibrand Clays (= Princetown Clays) with the Mornington and Muddy Creek (Lower) beds by Tate and Dennant (32) and by Murray (23), i.e., with beds regarded as belonging to the Balcombian marine stage of Tertiary sedimentation, is supported by the remarkable faunal and lithological similarities, although Murray (23) also correlated the Gellibrand Clays with beds at the Aire River and elsewhere along the Cape Otway coast, at localities where the beds are regarded as of (?)Janjukian age (Upper Oligocene to Lower Miocene) by Singleton (29). The beds near the mouth of the Sherbrook River (i.e., the coastal section at Rutledge's Creek) were correlated by Jenkins (19) with the Mordialloc (i.e., Beaumaris)

beds as Lower Pliocene. The upper layers of the deposits at Beaumaris have recently been classed as of Cheltenhamian (Upper Miocene) age (29).

The age assigned to the greater proportion of the Tertiary deposits N.W. of the Gellibrand River, from the present investigations, is Balcombian (Middle Miocene) and (?)Balcombian. The area, therefore, provides us with perhaps the finest and most extensive sections of Balcombian rocks yet recorded from Victoria. The following notes supply additional information concerning the nature of the Tertiary deposits and their fossil content. The mineralogical and petrological characters of the various rock types represented in the Port Campbell district have also been investigated.

Structural Features.

The Tertiary deposits of the coastal strip appear in the cliff sections between Peterborough in the west, and Glenample Steps in the east, mainly as a horizontal series of strata (Pl. II., figs. 1 and 3). Their horizontal disposition is accentuated by the formation of prominent, level, wave-cut platforms, wave-cut notches and storm benches, which have been developed along the bedding planes separating strata of slightly different solubility and hardness. The coast trends in a north-westerly direction in the eastern portion of the area, and east-west in the western portion. There is a general gentle seaward inclination (Pl. II., fig. 2) in the beds of up to 5°, as can be observed in transverse sections. At the Baker's Oven Rock and on the west side of the harbor at Port Campbell, dips of from 2° to 4° are present, while lower dips of about 1° occur at Loch Ard Gorge, London Bridge, in a bayside cliff west of the Amphitheatre, &c. The early geological survey officers, Wilkinson (34) and Murray (23), recorded the dip of the beds near the Gellibrand River (Pl. II., fig. 4) as 5° to the north-west, but Tate and Dennant recorded the dips as 4° in a west 12° south direction (32, p. 213). These are the maximum dips for the Tertiary beds west of the mouth of the Gellibrand River and east of Peterborough. Lower dip values result from the variable directions in which local coastal indentations cut across the direction of true dip. South-east of the mouth of the Gellibrand River, at small headlands in the vicinity of Pebble Point, the Eocene deposits dip at angles of 5° in much the same direction as the younger Tertiary sediments west of the river mouth (1). Low dips thus occur in the coastal sections both between Point Ronald (at the mouth of the Gellibrand River) and Pebble Point and between Point Ronald and Glenample Steps, but east and west of these localities the beds are more or less horizontal. Wilkinson recorded easterly dips in the Tertiary beds 40 chains west of the mouth of the Gellibrand River, and he considered that the Miocene strata 3

miles north-west of the river mouth occurred at the apex of an anticlinal curve (34, and see fig. 2). The author is unable to agree with these observations, having found that clays and sands 40 chains west of the Gellibrand River dip westerly 5° (Pl. III., fig. 12). No anticlinal structure was found 3 miles north-west of the Gellibrand River. The broad, shallow syncline at Peterborough, shown by Wilkinson in fig. 2, is proved by the disappearance of the Tertiary clays below sea level for about a mile on each side of Curdie's Inlet. Elsewhere in the coastal cliffs east and west of Peterborough, the clays form the lower 40′-60′ of the cliffs. The Curdie River apparently followed this synclinal structure.

The direction of elongation of certain of the rock stacks, gorges and heads of bays, and the trend of prominent cracks on wave-cut benches, indicate that some of the joint planes in the Tertiary rocks are parallel with the general trend of the coastline (i.e., N.W.-S.E. in the western part of the area). Others trend N.E.-S.W., parallel with other gorges and promontories in the central to eastern portion of the area. Some of the joint planes are vertical, and so control the nature of the cliff faces, others dip into the cliff faces at lower angles (e.g., west wall of Loch Ard Gorge, where the joints dip at 45°) and control the slope of the roofs of caves. Jointing in the Tertiary clays south-east of Glenample Steps is closely spaced, and appears to have resulted from recent alternate wetting and dessication of steeply inclined cliff faces (Pl. III., fig. 10).

Intraformational contortion in a band of highly plastic clay about 6 feet wide occurs among the dipping Tertiary series south-east of Glenample Steps (Pl. III., fig. 8). It can be traced for a few chains in the cliffs, and probably resulted from the movement of hydrated clays under the influence of the pressure of the overlying beds (18, Pl. 1), or from subaqueous slumping (18, p. 15).

Many of the bedding planes in the Tertiary rocks, especially those in the upper portions of the cliffs are marked by concentrations of nodules and sheets of secondary calcium carbonate (Pl. II., figs. 3 and 4), the nodules assuming rounded, cylindrical and irregular shapes.

The Tertiary beds throughout the area form an apparently conformable series, although, at Curdie's Inlet, Wilkinson stated that the soft, yellow limestone containing a few fossils, appeared to rest unconformably upon the underlying calcareous clays, since the limestone filled up small hollows in the upper beds of the calcareous clays (34). The Tertiary beds in the south-eastern portion of the area are unconformable to the Jurassic beds, while the base of the overlying non-stratified post-Miocene clays in the

western and central portions of the area is sharply delimited from the Tertiary deposits. The Pleistocene dune limestone rests unconformably upon Eocene, (?)Oligocene and Miocene sediments.

Wilkinson recorded numerous small faults in the cliff sections at Port Campbell; five or six were said to occur in a short distance (1 mile) (34). A few faults observed by the author are thrust faults; a small one in a cliff section north-west of Castle Rock has a stratigraphical throw of about 2 feet, and a hade of 25° in an east of south direction. Others of like nature occur in the cliffs west of Sherbrook River and in Thunder Cave at the head of Survey Gorge, half a mile west of Loch Ard Gorge. Minor variations in height of the more clearly-marked junctions between certain beds in less accessible portions of the cliff faces may be due to small faults, but may have resulted from local warping of the gently dipping strata.

In the western portion of the area, local sagging of the limestone beds in the vicinity of the Grotto has resulted in small-scale collapse structures (Pl. II., fig. 6). The motive force responsible for their development is gravity (17). The limestone has been bent and broken by slipping over calcareous clay deposits into caves dissolved in the underlying beds. Similar small-scale, monoclinal flexures are less clearly marked in the cliffs of the immediate neighbourhood.

Chemical banding by the rhythmic precipitation of colloidal iron oxide occurs in patches in the Tertiary limestones and calcareous clays as at the Amphitheatre, at the Rutledge's Creek coastal section, and in the cliffs near Hennessy Steps (east of Broken Head).

In the Jurassic sediments outcropping in the south-eastern portion of the area, current bedding and honeycomb and cannonball structures have been brought into prominence by differential weathering.

Stratigraphical and Palaeontological Relationships.

Eocene.

The nature and relationship of the westerly dipping Eocene beds, with a strong littoral fauna, S.E. of the Gellibrand River mouth, have already been described (1, 30, 33). Since that description, W. J. Parr has found an outcrop of fossiliferous, glauconitic clay at a locality about 1 mile N.W. of Pebble Point, near the two recorded bands of sandstone, one containing *Turritella* sp. and the other *Trochocyathus* with *Odontaspis*. Foraminifera, corals, pelecypods, gasteropods, scaphopods and shark's teeth occur in the glauconitic clay. Mr. Parr has examined

the foraminifera and concluded that the assemblage is similar to that in the Pebble Point Beds (Eocene). This evidence lends further proof to the conclusion drawn from the lithological character and disposition of the sediments immediately above the Pebble Point Beds (1), that they are also of Eocene age. The Eocene deposits south-east of the Gellibrand River, therefore, include the Pebble Point Beds and the overlying fossiliferous clays with intercalated sandstone beds, up to the base of the non-fossiliferous sandy clays and ferruginous sandstones which occur half a mile south-east of Point Ronald.

(?)Oligocene.

Unfossiliferous beds immediately above the Eocene, which have the same dip in the same direction as the Eocene deposits, may be of Oligocene age, but there is as yet no conclusive evidence to establish this. A bed of carbonaceous sandstone in this series bears certain lithological resemblances to carbonaceous sandstone at Anglesea in Victoria, but does not contain *Odontaspis contortidens* (Ag) or *Cyclammina*, which have been recorded from the Anglesean series, classed as Oligocene (29). The lowest (unfossiliferous) beds of the westerly dipping Tertiary deposits on the other side (i.e., north-west) of the Gellibrand River have no counterparts among those of unproven age which rest conformably upon the Eocene. This, and the fact that the direction and amount of dip are similar for outcrops on each side of the river mouth, lead to the assumption that the oldest beds exposed N.W. of the Gellibrand are younger than the youngest beds exposed S.E. of the river. This again, however, is not conclusive, because nothing is known of the beds or structures that existed in the gap created in the Tertiary rocks by the pre-Pleistocene ancestor of the Gellibrand River. If a continuous series of westerly-dipping beds is hidden beneath the Quaternary deposits at this locality, it should, according to calculations, be some 350-400 feet thick.

Miocene.

Extending for a distance of 2 to 2½ miles west of the mouth of the Gellibrand River, various exposures of the Tertiary beds form the lower 30 to 40 feet of the cliffs, but in many places between Point Ronald and Glenample Steps are obscured by large talus deposits (Pl. III., fig. 9) derived mainly from Pleistocene dune limestone. The Pleistocene forms the upper parts of the cliffs from a few yards east of Glenample Steps to within 30 chains of Point Ronald (at the mouth of the Gellibrand River), after which it comes down to sea level and forms the entire cliffs at Point Ronald (fig. 3), and the wave-cut platform and reefs half-a-mile south-east of the mouth of the Gellibrand River.

Thirty chains west of the Gellibrand River mouth, Wilkinson (34) recorded east-dipping Tertiary rocks, and at a section 10 chains further west he found 7 feet of unfossiliferous, blue, sandy clay with a few quartz pebbles, overlain by 20 feet of yellow, red and grey sandy clay with no fossils. The author found that these are really west-dipping Tertiary beds at this locality (Pl. III., fig. 12). Half-a-mile north-west of Point Ronald, outcrops of Tertiary beds, occasionally visible among piles of large fallen blocks of dune limestone, consist of ferruginous gritty sandstone, about 15 feet thick at the base (lower limit hidden by Recent beach sands), with occasional bands of dense ironstone but no fossils visible in hand specimens. This is overlain by a lenticular bed 1-8 feet thick (Pl. III., fig. 11), containing abundant ferruginous pebbles 3-4 inches across, and ferruginous internal casts and external moulds of gasteropods like *Cypraea* sp., &c. On breaking, some of the pebbles are seen to contain casts of pelecypods. Sharks' teeth are also present in the matrix of the deposit. Wilkinson regarded the pebbles as rolled fragments of fossiliferous Miocene clays (34). Some of the matrix in which the pebbles are set consists of ferruginous gritty sandstone comparable to the underlying bed, and some of the pebbles are phosphatic. The fossil casts and moulds appear to belong to the deposit (i.e., not remanié), and are merely replaced by ironstone. Gritty limestone containing a band of ironstone 1 foot thick overlies the conglomerate, and forms part of the matrix in which the ferruginous, phosphatic nodules are set. A Janjukian shelly fauna occurs in this bed and in the overlying limestone. Forms such as *Graphularia senescens* (Tate), *Mopsea* cf. *coralloides* Ed. & H., *Flabellum distinctum* Ed. & H., various additional types of corals, *Paradoxechinus novus* Laube, *Lovenia forbesi* (T. Woods), echinoid spines, *Cellepora gambierensis* T. Woods, *Schizellozoon* sp., *Spondylus gaderopoides* McCoy, *Chlamys*, *Pallium* (*Mesopeplum*) aff. *palmipes* (Tate), *Willungia tasmanica* Powell, *Umbilia* cf. *platyrhyncha* (McCoy), *Conus* sp., and sharks' teeth, are present in this matrix. Additional features are large Nodosarians, well preserved Cidaroid spines, and round, brown-coloured grains of quartz about the size of a pea. The overlying gritty limestone is 15 to 20 feet thick, and contains abundant polyzoa and various echinoids, in addition to those fossils observed in the matrix of the ferruginous, phosphatic conglomerate. A few feet of fossiliferous clays, probably of Janjukian age, exposed above the gritty limestone, are overlain by Recent sands and talus. These clays contain a few species of foraminifera found in Janjukian beds in other parts of Victoria, but the greater part of the foraminiferal assemblage is composed of Balcombian species.

The outcrop of this series of beds can be traced along the beach section for about 40 yards. All of its members are conformable and dip $2\frac{1}{2}°$ westerly. At the north-west end of the exposure of ferruginous conglomerate and grits, fossiliferous blue and grey coloured clays appear. They are conformable with the beds containing macrofossils with a Janjukian aspect, and are westerly continuations of the clays resting upon the gritty limestone. The gritty limestone bed having a macro-fauna with Janjukian affinities may, with the clay immediately above it and the underlying non-fossiliferous beds, represent Upper Oligocene deposits, as Singleton (29) regards Janjukian beds as of Upper Oligocene to Lower Miocene age. There is no marked Batesfordian phase between the gritty limestone of Janjukian age, and the overlying conformable clays which grade into true Balcombian.

Further north-west of this locality, extending to about $2\frac{1}{2}$ miles from Point Ronald, grey Tertiary clays form fairly steep cliffs 30 to 40 feet high (Pl. III., fig. 9). The clays in the cliff sections here are of Balcombian age, and extend north-west to the dipping Balcombian clays so prominently exposed in the high cliffs nearer Glenample Steps (Gibson's Beach). They contain abundant Balcombian fossils including, among others, foraminifera (see appendix), corals, polyzoa, rare brachiopods and rare echinoids, numerous molluscs among which are *Limopsis morningtonensis* Pritchard, *L. maccoyi* Chapman, *Glycymeris gunyoungensis* Chapman & Singleton, *Pterospira hannafordi* (McCoy), *Ellatrivia minima minima* (T. Woods), *Zoila platypyga* (McCoy), *Gigantocypraea gigas* (McCoy), *Dentalium mantelli* Zittel and *D. subfissura* (Tate), and *Aturia australis* (McCoy). Abundant small gasteropods are also present.

The clays and argillaceous limestones in the cliff sections south-east of Glenample Steps (i.e., at the locality referred to in earlier works as "three miles west of the Gellibrand River mouth"), correspond with Wilkinson's No. 9 locality (34). They dip south of west at 5° at the eastern end of the exposures, but the angle of dip decreases to 2° at the first headland east of Glenample Steps. The beds become horizontal near Glenample Steps and remain more or less so for over 20 miles in a westerly direction along the coastline, after which they dip westerly at low angles.

The fossil species from the beds in the cliff sections three miles north-west of the mouth of the Gellibrand River, many (200) of which are listed by Tate and Dennant (32, p. 218-226) and by Dennant and Kitson (12), and the lithological characters of the beds are comparable to those of the Muddy Creek (Lower) and Balcombe Bay beds, which are regarded as of Middle Miocene

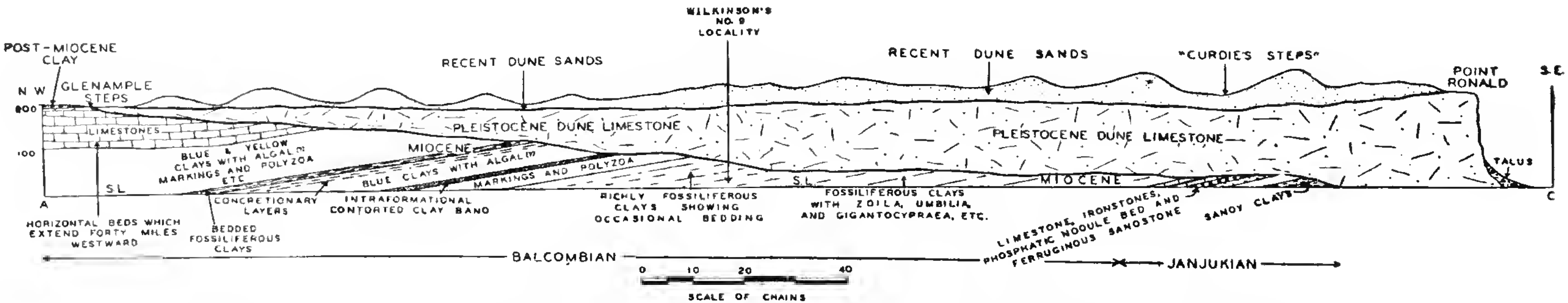

FIG. 3.—Geological Sketch Section, illustrating diagrammatically the coastal sections from Glenample Steps in the north-west to Point Ronald in the south-east. Length of section is just over 3½ miles. Heights above sea-level are up to 250 feet. The dip of the Tertiary beds is exaggerated.

age (29, p. 63-64). In parts, the clays are shale-like in appearance on account of the frequent parallel lineation of markings resembling algal remains. At this locality, a calcareous clay band containing *Umbilia eximia maccoyi* Schilder, *Umbilia leptorhyncha* (McCoy), *Zoila platypyga* (McCoy) and other gasteropods, occurs some 30 feet stratigraphically higher than another depositional phase of the clay containing *Cerithium apheles* T. Woods and *Gigantocypraea gigas* (McCoy). Between these two bands, and in the base of the cliffs further north-west of this locality, extending to Glenample Steps, the Lower Tertiary clays are chiefly blue-grey in colour. They contain numerous sinuous and concentric markings tentatively referred to as algal remains (Pl. III., fig. 7), a few species of foraminifera, *Ditrupa,* and sporadic patches with branching forms of polyzoa and molluscs. The curious branching and pipe-like markings which sometimes appear concentric in cross-sectional aspect, are alternating darker and lighter bluish-grey-coloured, laminated clay. They are often flattened, and although referred to as (?) algal markings, they do not show any definite plant-like structures. Dr. M. F. Glaessner has suggested to me the possibility of the markings being due to burrowing animals such as marine worms and the like. The remains of mud-haunting crabs and spatangoids in various parts of the Tertiary rocks suggest that the markings may be a result of their burrowing activities. Clays with similar markings occupy the base of the cliffs at Deany Steps, at Marble Arch, and immediately west of the mouth of the Sherbrook River where numerous echinoids (*Schizaster sphenoides* T. S. Hall, *Brissopsis tatei* T. S. Hall, *Maretia anomala* Duncan, *Eupatagus laubei* Duncan, &c.) and casts of *Turritella* sp. also occur. Balcombian clays similar to those occurring in the coastal sections north-west of Point Ronald, and equally rich in fossils, outcrop inland in small landslides (= Chapple's locality on the northern bank of Latrobe Creek, about half-a-mile from Princetown (9). At Deany Steps, (?) algal clays are exposed for at least forty feet above sea level. They overlie a narrow band of limestone, which forms the wave-cut platform here. This limestone is harder than the limestones higher up in the cliffs and is a pure form composed principally of minute foraminifera, gasteropods and occasional ostracods At Marble Arch, (?) algal clays also occur for forty feet upwards from the cliff base. They are overlain by friable limestones nearly white in colour, which represent leached portions of the younger limestone beds of the area. These beds contain Balcombian foraminifera.

Resting upon the (?) algal clays are shelly calcareous clays, argillaceous limestones and purer forms of soft and friable limestones (see upper part of Sentinel Rock in Plate II., fig. 2), which are only accessible in a few localities along the coastline, as at Rutledge's Creek, mouth of the Sherbrook River, the Amphitheatre, Deany Steps, London Bridge and Marble Arch. Because of the inaccessible nature of the intervening portions of the cliff sections, little can be said of the detailed characters of the sediments, but distant observations from the tops of the cliffs indicate no apparent variation in their nature from place to place. A detailed study of the more readily, but limited, accessible portions is, therefore, regarded as being sufficiently representative of the upper beds in general. Along portions of the coastline, fallen blocks from the higher parts of the vertical cliffs provide examples of fossils unrecorded from other localities in this part of the area. Thus, an example of *Paradoxechinus* was obtained from a fallen limestone block on Gibson's Beach. The stalk-eyed crab, *Ommatocarcinus corioensis* (Cresswell), which had previously been found at Two Mile Bay, associated with a few brachiopods and mud-haunting spatangoids (15), is a relatively common species in the (?) Balcombian limestones of the Port Campbell cliffs, occurring at Beacon Steps, Sherbrook River beach cliffs, Amphitheatre, Gravel Point, Rutledge's Creek, London Bridge, cliffs opposite Sentinel Rock, &c., where they have been collected both in situ and from fallen blocks. The soft basal clays containing (?) algal remains at the base of the cliffs in other accessible parts of the area are represented in the cliffs of Loch Ard Gorge by a dark indurated clayey rock containing examples of *Brissopsis tatei* T. S. Hall and "*Magellania*." Above this is a band of similar rock with patches containing abundant remains of *Ditrupa*, 15 to 20 feet above sea level. The lower beds in the cliffs are here overlain by limestones and argillaceous limestones.

At the Rutledge's Creek coastal section (= Wilkinson's No. 10 locality), where the beds are stratigraphically higher than the Gellibrand Clays by some 100 to 150 feet or more, a whitish to cream coloured limestone forming the wave-cut platform occurs in the base of the cliffs for up to about 6 feet above sea level. It is overlain by 10 to 15 feet of calcareous clay rich in molluscan and foraminiferal remains, and also containing numerous brachiopods, a few polyzoans, scaphopods, echinoids and cetacean bone fragments. Dr. F. A. Singleton has identified *Eotrigonia semiundulata* (Jenkins) and *Neotrigonia acuticostata* (McCoy) from this calcareous clay; both of these forms occur at the same level in a prominent storm notch (Pl. II., fig. 1), but elsewhere in Victoria they usually, though not always, occur on different horizons in the Tertiary series. Mr. O. P. Singleton has identified *Nototrivia subtilis* Schilder and *Ellatrivia minima*

(T. Woods), both of which are Balcombian species, from the Rutledge's Creek clay. The macro- and micro-fossil organisms from this clay are generally comparable with the fossil assemblage of the Gellibrand Clays (Balcombian), the main differences being the greater prominence of large cowries in the Gellibrand Clays, and the presence of the two forms of Trigonia and a few additional genera (usually indicating a younger age elsewhere in Victoria), in the Rutledge's Creek Clays. The calcareous clays at the Rutledge's Creek coastal section thus appear to constitute a slightly later phase than the typically Balcombian Gellibrand Clays. Above the calcareous clay band at Rutledge's Creek occur 10 to 15 feet of argillaceous limestone, then 20 feet of friable limestone, followed by 50 feet of soft, but purer forms of limestone (see Table 3). The Tertiary series here is covered by a veneer of post-Miocene clay deposits about 5-10 feet thick. The limestone beds in the upper parts of the cliffs are not as rich in fossils as the calcareous clays, but contain a few Balcombian species of foraminifera and scattered examples of *Brissopsis tatei* T. S. Hall, "*Magellania,*" *Serripecten yahlensis semilaevis* (T. Woods), polyzoa and crab remains. Additional fossil genera from the limestone beds of other parts of the Port Campbell district are the large echinoid *Linthia compressa* (Duncan), found high up in the cliffs at the Grotto, *Lovenia forbesi* (T. Woods) in the upper parts of the cliffs at the Amphitheatre, Broken Head, Sherbrook River beach, Castle Rock, Point Hesse and Peterborough (Wilkinson's No. 11 locality), *Clypeaster cf. gippslandicus* McCoy at 45 feet above sea level at Hennessy Steps, at 15 feet above sea level on the west bank at the mouth of Rutledge's Creek, and 54 feet above sea level in a prominent notch at the Amphitheatre. One example of *Isurus* was found in the clays of post-Miocene age on the Tertiary limestones at Gravel Point; this form has a matrix of limestone identical with the limestone of the underlying Tertiary beds, and is therefore a remanié fossil derived from the Tertiary rocks.

The limestones of the Port Campbell coastal sections extend inland for some considerable distance. Outcrops of limestone and calcareous clays which occur at greater heights at Timboon, Curdie Vale, Jancourt and elsewhere contain foraminiferal assemblages similar to those in the Port Campbell limestones and clays. *Ellatrivia minima torquayensis* Schilder has been identified by Mr. O. P. Singleton from a specimen in the T. S. Hall collection collected inland from clays near the Port Campbell cheese factory. The prominent harder patches and sheets in the more friable limestones exposed in the coastal and inland sections sometimes contain similar fossils to those in the limestones. Dense, fine-grained portions are composed of echinoid spines and minute foraminifera, included in a dense calcareous base

stained in parts by limonite, and containing a few angular quartz grains. Such portions in the limestones are of concretionary character, and are partly of secondary origin.

At the Amphitheatre, one-half to three-quarters of a mile west of the Rutledge's Creek coastal section, the lower 30-35 feet of the cliff is inaccessible, but in the hanging valley of Ingle's Creek, bluish-grey coloured clays with "*Magellania*" underlie a hard calcareous band. This hard band is some six feet or so above the creek bed. Immediately underneath it *Ditrupa* is common. Above the hard calcareous band are some 65 feet of Tertiary sediments, starting with argillaceous limestone, from which *Schizaster sphenoides* T. S. Hall was obtained, and followed by a narrow bed of limestone, rich in comminuted shell fragments as well as complete shells. Overlying this is a layer showing well-developed chemical banding by iron oxide and a few fossils; this in turn is overlain by limestones with a calcareous clay band containing *Scutellina patella* Tate, *Brissopsis tatei* T. S. Hall, polyzoans, *Magellania garibaldiana* (Duncan), *Ostrea* sp., *Serripecten yahlensis semilævis* (T. Woods), *Cucullaea corioensis* McCoy, *Volutospina antiscalaris* (McCoy), *Dentalium mantelli* Zittel, &c. These are abundant on the east side of the Amphitheatre, in the face of a well-marked notch some six feet in height from floor to roof. The foraminiferal assemblage and many of the macro-fossils in this notch, which is 54 feet above sea level, are similar to those in the notch some ten feet or so above sea level at the Rutledge's Creek coastal setion. The difference in height in these two instances is due to either faulting or local warping of the Tertiary sediments. Above the calcareous clay band at the Amphitheatre are about 50 feet of argillaceous and purer forms of limestones. They contain sporadic occurrences of fossil species similar to those in the notch. Among these higher beds is another band rich in *Ditrupa*, overlain by a bed of limestone with occasional small pellets of glauconite. Ten to 15 feet of post-Miocene clays and Recent soils cap the Tertiary deposits at this locality.

The height of the lower Ditrupa beds at the Amphitheatre is 45 feet above sea level, the same height as occurrences at the top of the third storm bench above sea level at Hennessy Steps (a few yards east of Broken Head), where associated fossil forms are numerous branching and disc-shaped polyzoans and occasional echinoids. Chapman (3, p. 30) and Chapman and Crespin (5) attached some importance to the occurrence of *Ditrupa* in Victoria, stating that it was typical of Victorian Janjukian beds. Since the Ditrupa beds in the Port Campbell district are stratigraphically higher than the Gellibrand Clays, which are of Balcombian age (29), then the Janjukian beds would, on these views, be above the Balcombian beds. Singleton, however,

places the Balcombian above the Janjukian (29), and this is the condition near Princetown. Accordingly, the Ditrupa beds must be late Balcombian or younger because the typical Balcombian deposits exposed in the coastal sections of this region are considerably lower on the stratigraphical scale, occurring as dipping beds some miles further to the south-east, at the locality three miles north-west of the mouth of the Gellibrand River. Ditrupa cannot be regarded, therefore, as typically Janjukian in this area. Determinations of the foraminifera by Mr. W. J. Parr (see appendix) indicate that the majority of the Tertiary beds in the Port Campbell district, north-west and west of the Gellibrand River belong to the Miocene (Balcombian) era of the Tertiary division. Preliminary examination of the molluscs by Dr. F. A. Singleton indicates that the Gellibrand Clays are Balcombian, while stratigraphically higher clays at Rutledge's Creek have a mixed fauna, principally Balcombian, but with some forms suggesting Cheltenhamian affinities.

Post-Miocene.

Clays of still younger age than the Miocene deposits of the district have been designated post-Miocene clays. They rest upon the upper limestones of the Tertiary series, varying in thickness from 2 to 20 feet. The contact with the underlying Miocene beds appears to be in the nature of a disconformity, with an apparent old erosion surface in the Tertiary rocks, formed parallel to the more or less horizontal bedding planes in the Tertiary sediments (see Pl. II., fig. 3). This, however, is not the true explanation, as the post-Miocene clays are most likely residual clays formed from the dissolution of younger horizons of the Tertiary limestones. These clays are yellow, red, brown and bluish-grey in colour; the variable colouration arising from different degrees of iron staining and leaching. They are compact with rare, well-rounded pebbles of reef quartz and quartzite, occasional aboriginal flints, and a certain amount of sand. They are frequently associated with abundantly developed buckshot gravel which occurs both at the surface, and at depths of 18 inches below the top of the clays. Occasional mounds of massive hydrous iron oxide are also associated with these clays at Gravel Point, Point Hesse and elsewhere. The iron oxide in such deposits was probably derived from iron salts that are present in most natural waters; it is doubtful whether sufficient could have heen derived from the Tertiary sediments in the immediate neighbourhood. The post-Miocene clays contain remanié fossils derived from the Miocene limestones, and also occasional hard, nodular fragments of the limestone. The remanié fossils occur as fragments of *Serripecten, Magellania, Cellepora*, &c., which show signs of destruction by solution. The clays were, therefore, formed as residual deposits from the solution and weathering

of the higher members of the Miocene limestone series. This conclusion is supported by the fact that the limestones contain a certain percentage of clay constituents in their composition (see Table 3).

The post-Miocene clays nowhere come into contact with the Pleistocene dune limestone, consequently their age relationships can only be inferred from physiographical evidence. The past topography of the area was such that it appears likely that the post-Miocene clays had commenced to form before the ancestor of the Gellibrand River had eroded the wide valley in the Tertiary rocks, in which the Pleistocene dune limestone was ultimately deposited.

Pleistocene.

The Pleistocene dune limestone was deposited in at least three main stages. Murray records red sand beds about one or two feet thick between the calcareous sandstone beds, separating the series into layers 15, 40 and 50 feet thick, respectively (23, p. 129). Such interbedded material has come to be regarded in Victoria as representative of fossil soil horizons. The red bands are of limited lateral extent, occurring for no more than 200 yards in the Dune Cliffs at Princetown. Where they cut out, distinct breaks, representing bedding planes, continue between layers containing narrow bands (Pl. II., fig. 5), dipping at different angles (maximum 30°). As many as six such breaks are present in the river cliffs on the west bank of the Gellibrand River, about 300 yards from the river mouth, so there may be this number of depositional stages in the Pleistocene dune limestone. These stages are probably due to various eustatic changes of sea level during the Pleistocene Ice Age. The dune limestone shows the usual marked current bedding characteristic of similar rocks elsewhere in Victoria. It consists principally of comminuted shell waste, loosely cemented by secondary calcium carbonate, and is consequently of a porous nature. The degree of shell comminution and grain sorting suggests that these deposits were developed on shell banks and shelly beaches, where changes in the strength and direction of marine currents were pronounced. Occasional secondary hard bands of limestone, one to three inches thick, have been precipitated along some of the bedding planes, and small patches of recently formed red soil (terra rossa) are associated with the dune limestone west of a small quarry near Princetown. These recent patches of red soil represent the insoluble residue of clay and other mineral matter, left behind at the surface in depressions, after solution of the dune limestone. They are, therefore, comparable in origin with the red sandy beds intercalated within the dune limestone, and with the clays of post-Miocene age overlying the Miocene limestones of the district.

Holocene.

Recent deposits in the Port Campbell coastal area are represented by sand dunes, sand ridges, beach sands, and loose rudaceous deposits of angular character. The latter are formed from the older rock types, and consist of fallen blocks of Tertiary clays and limestones in some parts, Pleistocene dune limestone in others, and in parts they contain fragments of ironstone. The larger, angular fragments are set in a matrix composed partly of material derived from the post-Miocene clays, partly of smaller constituents from the Tertiary rocks. These deposits form large talus cones at the cliff bases, and perched talus cones on ledges situated at various heights up the vertical cliff faces. Patches of duricrust occur on non-vegetated portions of some of the Recent sand dunes, such as near the mouth of the Sherbrook River, and immediately east of Glenample Steps. Recent marine silts and sands, in part fossiliferous (23), occur along the lower reaches of some of the larger streams in the area, mixed with river-borne silts, sands and gravels. A well sunk through the floor of Port Campbell Creek (near the tennis courts) by a local resident, Mr. John Hennessy, revealed first 18 feet of Recent sands, and then two feet of shelly clays; the well ended in sands a short distance below the clay, and the sands immediately above the clay bed are said to have contained ti-tree remains. Recent clays and a bed of conglomerate two feet thick, overlain by clay, dune sands and kitchen midden materials, have infilled a small valley east of the mouth of the Sherbrook River. The pebbles in the conglomerate consist almost entirely of rounded fragments derived locally from the harder Tertiary limestone beds, and a few rounded ironstone fragments. This conglomerate is 12 feet above sea level and represents an old storm beach. It has been partially scoured out by recent marine activity.

The following table (Table 2) is a summary of the sequence of events in the history of the area as interpreted from several accessible cliff sections of varying height. It includes estimates of the thicknesses of the beds, wherever obtainable. The sequence was determined from a traverse in the direction of dip along the coastal sections, i.e., from S.E. to N.W. and W.

Table 2.

Geological Sequence in the Port Campbell Coastal District.

(Based on Wilkinson's and the author's observations.)

1. Jurassic, Calcareous felspathic sandstones (arkoses) and mudstones with nodules, carbonised wood and occasional small patches of coal. Occurs in the coastal sections from Pebble Point to Moonlight Head.

2. Time Interval Extending Through the Cretaceous.

3. Eocene. (*a*) Grits, massive ironstones and sandy ironstones with quartz pebbles and fragments of Jurrassic rocks. Fossiliferous beds with *Cucullaea psephea, Lahillia australica, Limopsis* sp., *Nuculana paucigradata, Dentalium gracilicostatum, Aturoidea distans, Nautilus victorianus, Callianassa* sp., Shark's teeth and fossil wood.—50 feet.

(*b*) Black and greenish-coloured clay with sulphides, copiapite, a few quartz pebbles and occasional shelly fossils. In middle of clay beds, felspathic sandstone bands from east to west, (i) a band with echinoid and pelecypod casts, (ii) a band with *Turritella* sp. and *Ditrupa*, (iii) a band with *Odontaspis, Cycloseris* and *Trochocyathus*.—125 feet and over.

(*c*) Red and yellow sandy beds, ferruginous and non-fossiliferous.—35 feet.

(*d*) Black carbonaceous clays and sandy clays, with gypsum and copiapite in parts.—40 feet.

(*c*) and (*d*) may possibly be of Oligocene age. The beds in this sequence comprise the dipping strata south-east of the mouth of the Gellibrand River, and include Wilkinson's Nos. 6, 7, and 8 localities (34). The deposits total some 250 feet in thickness, according to Wilkinson, but are probably nearer 1,000 feet thick (1). They occur in the coastal sections between the Gellibrand River and Pebble Point.

4. Gap in Sequence of Tertiary Beds (Due to Post-Miocene Erosion) and Probably Representing Oligocence Time. Area Occupied by Pleistocene Dune Limestone.

5. Upper Oligocene-Miocene (Janjukian).

(i) *a*. Blue sandy clays with a few quartz pebbles, but no fossils.—7 feet.

b. Yellow, red and grey sandy clay, with no fossils.—20 feet.

These are west-dipping beds 40 chains north-west of the mouth of the Gellibrand River.

(ii) *a*. Ferruginous gritty sandstone.—15 feet.

b. Ferruginous phosphatic conglomerate, with abundant fossils.—3-8 feet.

c. Gritty limestone with corals, echinoids, polyzoa, pelecypods, &c.—15-20 feet.

d. Fossiliferous clays.—20 feet.

The beds in Section 5 (ii) dip westerly at low angles and occur 40-50 chains north-west of the mouth of the Gellibrand River. They comprise an older phase than the true Balcombian sediments, and appear to be Janjukian on the evidence of the shelly fossil content, but a transition phase between the Janjukian and the Balcombian from the evidence of the foraminifera.

6. Miocene (Balcombian).

Grey and blue coloured clays with a variable shelly fossil content and traces of bedding planes dipping westerly at 5 degrees, outcrop at intervals between localities 50 chains north-west and 3 miles north-west of the mouth of the Gellibrand River. At three miles north-west of the Gellibrand, the sequence is:—

(*a*) Blue, stiff clay with many molluscs, corals, polyzoa, &c.—40 feet

(*b*) Yellowish calcareous clay with few fossils.—32 feet.

The total thickness of this series of sediments is calculated at about 650 feet, from the fact that they dip at 4-5 degrees and outcrop over a distance of two miles.

7. Miocene (? Balcombian).

Horizontal limestones and calcareous clays, 100 feet thick in some parts, up to 300 feet thick in other parts.

(i) *a*. Hard, yellowish to cream coloured limestone with few fossils.—6 feet.

b. Calcareous, bluish-grey coloured clay, rich in fossils. Argillaceous limestone with few fossils.—30 feet.

c. Yellow and whitish-coloured limestones with a few fossils.—54 feet,

The beds in 7 (i) occur at the Rutledge's Creek coastal section.

(ii) *a*. Bluish-grey coloured clays.—36 feet.

b. Argillaceous limestone, shelly limestone, richly fossiliferous calcareous clay, purer forms of limestone with some fossils.—65 feet.

The beds in 7 (ii) occur at the Amphitheatre.

(iii) *a.* Bluish grey coloured clays.—40 feet.
b. Argillaceous limestones, calcareous clays and purer forms of limestones.—200 feet.

The beds in 7 (iii) occur at Deany Steps.

The sequence of beds in 7 (i), 7 (ii), and 7 (iii) is generally similar in the cliffs from Castle Rock in the south-east to within half a mile of the Grotto in the west. Variations in total thickness at each of the several cliff sections examined result from cliff height variations and local warping in parts.

(iv) Soft yellowish limestone with few fossils, resting on calcareous clays similar to those in 7 (i) *b* at the Rutledge's Creek coastal section.—30-40 feet.

The beds in 7 (iv) occur in the vicinity of Curdie's Inlet. The beds in 7 are younger phases of the Miocene beds. They are regarded as ?Balcombian, being stratigraphically higher than the Balcombian of the coastal sections 3 miles north-west of the Gellibrand River, and having a somewhat different fauna.

8. Post-Miocene. Red, brown, yellow and blue-grey sandy clays with remanié fossils. These extend along the tops of the cliff sections from Glenample Steps to the Grotto.—2-20 feet.

9. Pleistocene. Dune limestones of the Gellibrand River area.—Up to 300 feet.

10. Recent.—Unconsolidated dune sands, beach deposits, red soils, alluvium, duricrust, &c.

Lithology and Mineralogy of the Sediments.

The lithological and mineralogical characteristics of the Jurassic and Eocene beds S.E. of the mouth of the Gellibrand River have been dealt with elsewhere (1).

(?) Oligocene.

The sandy clay 30 chains N.W. of Point Ronald is a rather incoherent sediment which rapidly sludges in water. Seventy-one per cent. of the deposit consists of almost pure white quartz sand of even grade size, the grains being 0.2-0.8 mm. across. The quartz grains are well rounded, some are translucent, some are opaque, partly as a result of pitting by abrasion, very few are sub-angular or iron-stained. A small amount of andalusite and rare grains of both blue and brown tourmaline are present in addition to the minerals listed in Table 3. The ferruginous gritty sandstone from the cliff section half-a-mile north-west of the mouth of the Gellibrand River consists of rounded and angular quartz grains and limonite pellets with a few foraminifera, coral fragments, felspar grains, and quartzite fragments, set in a partly calcareous, partly ferruginous base. Similar materials occur in the matrix of the overlying ferruginous phosphatic conglomerate, which also includes matrix material identical with the overlying gritty limestone. The quartz grains in the limestone are up to 0.4 mm. long, opaque, white and translucent, and principally well-rounded. These are set in a calcareous base containing abundant micro-organisms—foraminifera, echinoid spines, &c., and fragments of polyzoa and shelly fossils. Fossil structures are partially replaced by ferruginous matter.

TABLE 3.—MINERAL COMPOSITIONS OF SOME PORT CAMPBELL ROCKS. (ROCK TYPES ARRANGED IN STRATIGRAPHICAL ORDER).

	Rock.	Locality.	Percentage Soluble Fraction.	Percentage Clay.	Percentage Sand.	Rounded Quartz.	Angular to Sub-Angular Quartz.	Felspar.	Mica.	Glauconite (Oolitic and/or Foram. Casts.)	Gypsum.	Ilmenite and/or Magnetite	Limonite.	Pyrite.	Tourmaline.	Cassiterite.	Zircon.	Rutile.	Number.
Quaternary.	Beach sand ..	Picnic Steps, 5 chains N. E. of Sentinel Rock	70	—	30	(x)	—	—	—	—	—	+	+	—	+	—	+	—	1
	Dune limestone ..	Quarry, 1 mile west of Princetown	93	tr.	7	(x)	+	+	—	—	—	+	+	—	+	—	+	+	2
	Duricrust	Mouth of Sherbrook River.. ..	70·5	0·7	28·8	(x)	+	—	—	—	—	+	+	—	+	+	+	—	3
	Post-Miocene clays ..	Broken Head	6	66·5	27·5	+	(x)	+	—	—	—	+	+	—	+	+	+	+	4
M. Miocene.	Soft limestone ..	88′ above sea level, Rutledge's Beach	91	8	1	+	(x)	+	—	+	+	+	—	—	+	—	+	+	5
	Soft limestone ..	73′ above sea level, Rutledge's Beach	85	13·5	1·5	+	(x)	+	—	+	—	+	+	—	+	—	+	—	6
	Friable limestone ..	40′ above sea level, Rutledge's Beach	86	14	tr.	+	(x)	+	—	—	+	+	+	—	+	—	+	—	7
	Argillaceous limestone	20′ above sea level, Rutledge's Beach	79	21	tr.	+	(x)	+	—	+	—	+	+	—	+	—	+	—	8
	Upper calcareous clay	12′ above sea level, Rutledge's Beach	53	47	tr.	—	+	+	+	+	—	+	+	—	—	—	—	—	9
	Harder whitish limestone	Wave platform. Rutledge's Beach ..	95	5	tr.	—	+	—	+	—	—	+	—	—	—	—	+	—	10
	Harder grey limestone	Wave platform. Deany Steps ..	98	2	tr.	—	+	—	—	—	—	+	—	—	—	—	—	—	11
	Lower calcareous clay	Beach section 2½–3 miles N.W. of Point Ronald	36	64	tr.	—	+	—	+	+	+	+	—	+	—	—	+	—	12
L. Miocene.	Lowest calcareous clay	50 chains N.W. of Point Ronald ..	37·5	62	0·5	—	+	+	+	+	+	+	+	+	+	—	+	—	13
	Gritty limestone ..	50 chains N.W. of Point Ronald ..	74·6	3·9	21·5	(x)	+	+	+	+	—	+	+	—	+	—	+	+	14
	Sandy clay.. ..	½ mile N.W. of Point Ronald ..	nil	29	71	(x)	+	—	—	—	—	+	+	—	+	—	+	+	15

(x) = more common type of quartz grains.

Table 3 illustrates the acid solubility and mineral content of the more readily accessible Tertiary and Quaternary rocks from various localities along the coastal sections in the Port Campbell-Princetown district. The soluble fraction is composed principally of calcium carbonate, but small amounts of soluble iron compounds are also present. The sand fractions are composed principally of quartz. The heavy minerals are only represented by one or two grains of each species, except for limonite and ilmenite, which are more frequent. The felspar consists of plagioclase, microcline and orthoclase-perthite; the mica is present as a few flakes of brown and bleached biotite. Most of the mineral species were derived from the Jurassic arkoses and mudstones which formed the adjacent coastline at the time of deposition of the Middle Tertiary sediments. A peculiarity of some of the clays from the dipping Tertiary beds, $2\frac{3}{4}$-3 miles north-west of the mouth of the Gellibrand River, is the ease and rapidity with which they sludge in water. The constituents of such clays are almost entirely under 0.2 mm. across.

Miocene.

In the lower calcareous clays from the cliff sections north-west of the Gellibrand, most of the soluble fraction is due to the abundance of foraminifera and polyzoa. Casts of some of these organisms remained after acid treatment. Quartz grains are few in number in these clays and are subangular in outline, with a maximum size of 0.1 mm. The clay content is greater in these rocks than in the other Tertiary lithological types, and is in part gypseous. Pyrite occurs as minute rounded pellets and rods, and as larger nodules up to 3 inches long.

The hard, grey-coloured limestone constituting the wave-cut platform at Deany Steps contains only a minute quantity of sand. Most of the small percentage of insoluble matter consists of minute clay particles. Small forms of foraminifera, polyzoa, molluscs and ostracods are set in a calcareous matrix in this limestone. The softer limestones in the cliffs at this locality contain occasional flints.

The limestone of the wave-cut platform at Rutledge's Creek has a somewhat greater percentage of insoluble matter (mainly clay) than that at Deany Steps, and is not of so compact a nature. The calcareous clay, 12 feet above sea level at Rutledge's Beach, is more calcareous than the stratigraphically lower calcareous clay three miles north-west of the mouth of the Gellibrand River, mainly because at the locality where it was sampled, a molluscan fauna is profusely developed. Above this clay, the beds in the cliffs at Rutledge's Beach grade into argillaceous limestone which becomes purer as the percentage of clay decreases in the limestones higher up the cliffs, where gypsum also appears in small quantities. The limestones forming the higher portions of the

cliffs in the Port Campbell district are fine-grained, the matrix being of clay grade in which complete, large and small fossil organisms are embedded.

A few glauconitic casts of foraminifera and other micro-organisms appear in the sand fraction of certain of the limestones and calcareous clays. In parts, the glauconite has been altered and replaced by limonite. A marked feature of portion of the limestone beds above the pronounced notch at the Amphitheatre is the abundance of small dark-coloured spots of glauconite, which proved to be pellets and micro-fossil casts.

Post-Miocene.

The post-Miocene clays contain a small proportion of soluble carbonate. One grain of garnet and one grain of cyanite were seen in addition to the minerals listed in Table 3 (No. 4). The larger grains of quartz are well rounded, the smaller ones are sub-angular, and some of the quartz is of amethystine colour. The range in size of the quartz grains is 0.02 to 0.5 mm. across. The comparative clay-sand content for the post-Miocene clay and the Tertiary limestone from which the post-Miocene clay was derived is as follows:—

Tertiary Limestone: 9 of sand to 1 of clay

Post-Miocene Clay: 1 of sand to 3 of clay.

Pleistocene.

The soluble fraction of the dune limestone in the Princetown district is comparable in amount with that for consolidated dune rock from Limestone Hill, Cashmore, in the Portland district (11). The dune limestone contains foraminiferal, polyzoal, echinoid and molluscan fragments. The sand grains are not as well rounded as in the beach sands of the district, and quartz is sometimes of amethystine colour, ranging in size from 0.05 to 1.25 mm. Numerous cavities occur between the sand grains in the rock, but there are areas where dense calcareous bands occur. Clear calcite frequently forms rims around some of the quartz grains, and infills cavities in some of the foraminifera and smaller forms of gasteropods. A thin section of the red sandy beds in the Pleistocene dune limestone reveals rounded quartz grains and fragmentary fossil organisms set in a limonite-stained calcareous base.

Recent.

In the duricrust from the sand dunes at the mouth of the Sherbrook River, quartz grains are abundant and well rounded. They are mainly colourless, but occasionally pink, and range in size from 0.2 to 1 mm. In the beach sands, the quartz grains are mostly well rounded, ranging in size from 0.4 to 1 mm., with the majority over 0.5 mm. across. It is therefore apparent that few of the quartz grains were derived from the post-Miocene

clays (0.02 to 0.5 mm.), most coming from the Jurassic sandstones and Pleistocene dune limestone. The soluble content of the beach sands is due to comminuted shell waste, echinoid spines, foraminifera, &c., many of which were derived from the fossiliferous Tertiary rocks in the cliffs.

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Explanation of Plates.

PLATE II.

Fig. 1.—Horizontal Miocene (?Balcombian) calcareous clays overlain by limestones, Rutledge's Creek coastal section. The apparent dip of the beds is due to the uneven surface of the beach. The notched clays at the cliff base are richly fossiliferous.

Fig. 2.—Conformable Miocene (?Balcombian) clays and limestones with low angle of dip in a south westerly direction at Sentinel Rock (= the Haystack), 236 feet high,

Fig. 3.—Miocene (?Balcombian) strata with horizontal bedding planes marked by calcareous sheets and nodules of secondary origin, and overlain by post-Miocene clays, Castle Rock.

Fig. 4.—Fossiliferous Balcombian calcareous clays dipping 3 degrees south of west, and overlain by Miocene (Balcombian) limestones and Pleistocene dune limestone. Three miles north-west of the mouth of the Gellibrand River.

Fig. 5.—Pleistocene dune limestone showing current bedding. Talus cone at base of dune limestone cliff, and unconsolidated calcareous dune sand (Recent) on terrace cut in Tertiary rocks 40 feet above sea level. Two and a half miles north west of the mouth of the Gellibrand River.

Fig. 6.—Collapse structure- monoclinal fold caused by slumping of limestone beds into solution cave. Post-Miocene clays with buckshot gravel cap the Miocene limestones. Promontory on east side of the Grotto Bay.

Fig. 7.—Dark markings (? algal) in grey Balcombian clays. Three and a quarter miles north-west of the mouth of the Gellibrand River.

Fig. 8.—Intraformational contortion of Balcombian clays. Three and a quarter miles north-west of the mouth of the Gellibrand River.

Fig. 9.—Cliffs of Balcombian clays partially masked by talus deposits of Pleistocene dune limestone. Two and a quarter miles north-west of the mouth of the Gellibrand River.

Fig. 10.—Jointed Balcombian clays. Two and three-quarter miles north-west of the mouth of the Gellibrand River.

Fig. 11.—Janjukian beds with a low westerly angle of dip. Nodule bed below, and limestones, with ferruginous bands above. About 50 chains north-west of Point Ronald.

Fig. 12.—Westerly dipping ? Oligocene, non-fossiliferous sandy clays, half a mile north-west of Point Ronald.

Appendix.

The Foraminifera of the Tertiary Beds Exposed in the Coastal Sections between the Mouth of the Gellibrand River and Curdie's Inlet.

By W. J. PARR.

The material examined consisted of washings and selected specimens received from Mr. G. Baker, M.Sc., and four samples, one collected by Rev. George Cox, and the others by the writer. Details of these are as follows:—

SAMPLE. 1.—From gritty limestone, apparently largely bryozoal, ½ mile north-west of Point Ronald. (Coll. G. Baker, M.Sc.).

The material consists of bryozoa with numerous well-developed foraminifera, 58 species of which were recognized. The commonest are *Dentalina soluta*, *Guttulina problema*, *Globulina* sp., *Sigmoidella* sp. aff. *kagaensis*, *Cassidulina subglobosa*, *Cibicides* sp. aff. *pseudoungerianus*, and *Dorothia* sp. aff. *parri*. These are found in the Balcombian and the Janjukian of Victoria. Two other species which occur have a more limited distribution, *Discorbis* sp. nov. (of *D. bertheloti* group) being, with the exception of records from Waurn Ponds and Birregurra, known only from the Janjukian of Torquay, in which it is common, while *Calcarina* sp. aff. *verriculata* occurs in the Janjukian limestones at the mouth of Spring Creek.

SAMPLE. 2.—Clays immediately overlying gritty limestone ½ mile north-west of Point Ronald. (Coll. G. Baker.)

The washings are rich in well-preserved foraminifera, of which 82 species were separated. All of the more common forms in Sample 1 are present in addition to *Sigmomorphina chapmani* (described from the Miocene limestone of Batesford), *Bulimina* sp. nov. (common in Tertiary of Castle Cove), *Discorbis* sp. nov. (same species as in Sample 1), *Spiroloculina canaliculata*, *Cyclammina* sp. cf. *complanata*, *Liebusella antipodum* (common in Janjukian of Torquay, also noted from Tertiary of Lake Gnotuk), and *L. rudis* (only Victorian record is from Balcombian). The bryozoan, *Otoniella cupola*, var. *spiralis* is also present.

SAMPLE 3.—Selected foraminifera from clays in cliffs, west of "Curdie's Steps" about ¾ mile north-west of Point Ronald. (Coll. G. Baker.)

There are 22 species of foraminifera, the assemblage being a typically Balcombian one, including *Cibicides victoriensis* (very fine examples), *Ceratobulimina* (*Ceratocancris*) *hauerii*, var. *australis*, *Dorothia* sp. nov. aff. *karreri*, *Carpenteria proteiformis* and the usual miliolines.

SAMPLE 4.—Selected foraminifera from dipping clays, 2¾-3 miles north-west of Point Ronald (mouth of Gellibrand River). (Coll. G. Baker.)

There are 17 species of foraminifera, including *Cibicides victoriensis* (very typical), *Ceratobulimina* (*Ceratocancris*) *hauerii*, var. *australis*, and other Balcombian species.

SAMPLE 5.—Three miles north-west of mouth of Gellibrand River. (Coll. G. Baker.)

The washings consist principally of foraminifera with abundant *Globigerinae*. There are 58 species of foraminifera including *Uvigerina interrupta* (Balcombian, Recent), *Ehrenbergina* sp. nov. aff. *mestayeri* (Balc.), *Ceratobulimina* (*Ceratocancris*) *hauerii*, var. *australis* (Balc.), *Hofkerina semiornata* (Balc.), *Globigerinoides ruber* (common—the only previous Victorian Tertiary record is from the Miocene limestone of Batesford), *Globigerina dehiscens* (Balc.), and *Dorothia* sp. nov. aff. *karreri* (Balc.). There are also many examples of a peculiar form related to Jedlitchka's genus *Candorbulina*. This assemblage is undoubtedly Balcombian in age.

SAMPLE 6.—Clays from Gibson's Beach, 3½ miles north-west of mouth of Gellibrand River. (Coll. Rev. G. Cox.)

Forty-six species of foraminifera. All are Balcombian forms. The only noteworthy species is *Miniacina miniacea*, which is known from Balcombe Bay, the lower beds at Muddy Creek, and the Batesford limestone.

SAMPLE 7.—Hard grey argillaceous limestone from about 80 feet above base of cliff, up pathway at Gibson's Steps. (Coll. W. J. Parr.)

Forty-two species of foraminifera were recognized. The only species of note are *Cibicides* sp. aff. *victoriensis* (a Balcombian form) *Ceratobulimina* (*Ceratocancris*) *hauerii*, var. *australis* (Balc., common), *Liebusella rudis* (Balc., large typical specimens common), and *Textularia* sp. nov. aff. *carinata*. The age is Balcombian.

SAMPLE 8.—Selected foraminifera and washings from clay at 12 feet above sea level, east side of mouth of Rutledge's Creek. (Coll. G. Baker.) Other material collected by the writer from the same bed was also examined.

This material is rich in species of foraminifera, 138 being recognized. They include *Sigmomorphina* spp., *Bolivinella* sp. nov., *Pavonina triformis, Discorbis papillata* (Balc.), *D.* sp. aff. *corrugata* (previously known only from lower beds, Muddy Creek), *Cancris intermedia* (Balc.), *Cibicides* sp. aff. *victoriensis, Elphidium parri, E. subinflatum* (Batesford and lower beds, Muddy Creek), *Planispirinella exigua* (Balc. and Recent), *Biloculinella angusta* (Balc., and Janjukian of Torquay), *Textularia* sp. nov. aff. *carinata, Gaudryina collinsi* (Western Beach, Geelong, apparently Balcombian), *Carpenteria rotaliformis,* and *Dorothia* sp. nov. aff. *karreri* (Balc.). The bryozoan, *Otoniella cupola,* var *spiralis,* and the annelid, *Ditrupa,* also occur.

Sample 9.—Washings from argillaceous limestone at 20 feet above sea-level, east side of mouth of Rutledge's Creek. (Coll. G. Baker.)

There are fourteen species of foraminifera, the only species at all common being *Cibicides* sp. aff. *pseudoungerianus, C. victoriensis* (Balc.), *Orbulina universa,* and *Textularia* sp. nov. aff. *carinata.* Fragments of the tubes of the worm *Ditrupa* and the coral *Mopsea* also occur.

Sample 10.—Washings from friable limestone at 40 feet above sea level, east side of mouth of Rutledge's Creek. (Coll. G. Baker.)

There are 25 species of foraminifera, the predominant forms being the same as in Sample 6. Spines of a spatangoid sea urchin are common and there are a few bryozoans.

Sample 11.—Washings from soft limestone at 73 feet above sea level, east side of mouth of Rutledge's Creek. (Coll. G. Baker.)

Thirty-one species of foraminifera were recognized, including *Cibicides* sp. aff. *pseudoungerianus, C. victoriensis, Globorotalia dehiscens,* and a new, large, smooth species of *Bolivina.*

The samples from the mouth of Rutledge's Creek represent two facies of the Balcombian, one argillaceous from low down in the cliffs, and the other calcareous from the upper portions of the cliffs.

Sample 12.—Selected foraminifera from Notch, 54 feet above sea level, Amphitheatre, about ¾ mile west of mouth of Rutledge's Creek. (Coll. G. Baker.)

Thirty-one species of foraminifera. They include *Sigmoidella kagaensis, Cancris intermedia, Cibicides* sp. nov. (occurs also at mouth of Rutledge's Creek, 12 feet above sea level), *C.* sp. cf. *victoriensis, Planispirinella exigua,* and *Dorothia* sp. nov. aff. *karreri.* The age is Balcombian.

Sample 13.—Washings from blue-grey calcareous clay at base of cliffs, Deany Steps. (Coll. G. Baker.)

There are 43 species of foraminifera, including *Ceratobulimina (Ceratocancris) haueri,* var. *australis, Epistomina elegans* (common), 3 spp. of *Globorotalia, Textularia* sp. nov. aff. *carinata* (common), and *Martinottiella bradyana.* A Balcombian age is indicated.

Sample 14.—Limestone from base of cliffs just west of mouth of Curdie's Inlet. (Coll. W. J. Parr.)

Thirty-nine species of foraminifera. The commonest forms are *Liebusella rudis, Sigmoidella* sp. aff. *kagaensis,* and *Elphidium parri.* The species are all found in the Balcombian.

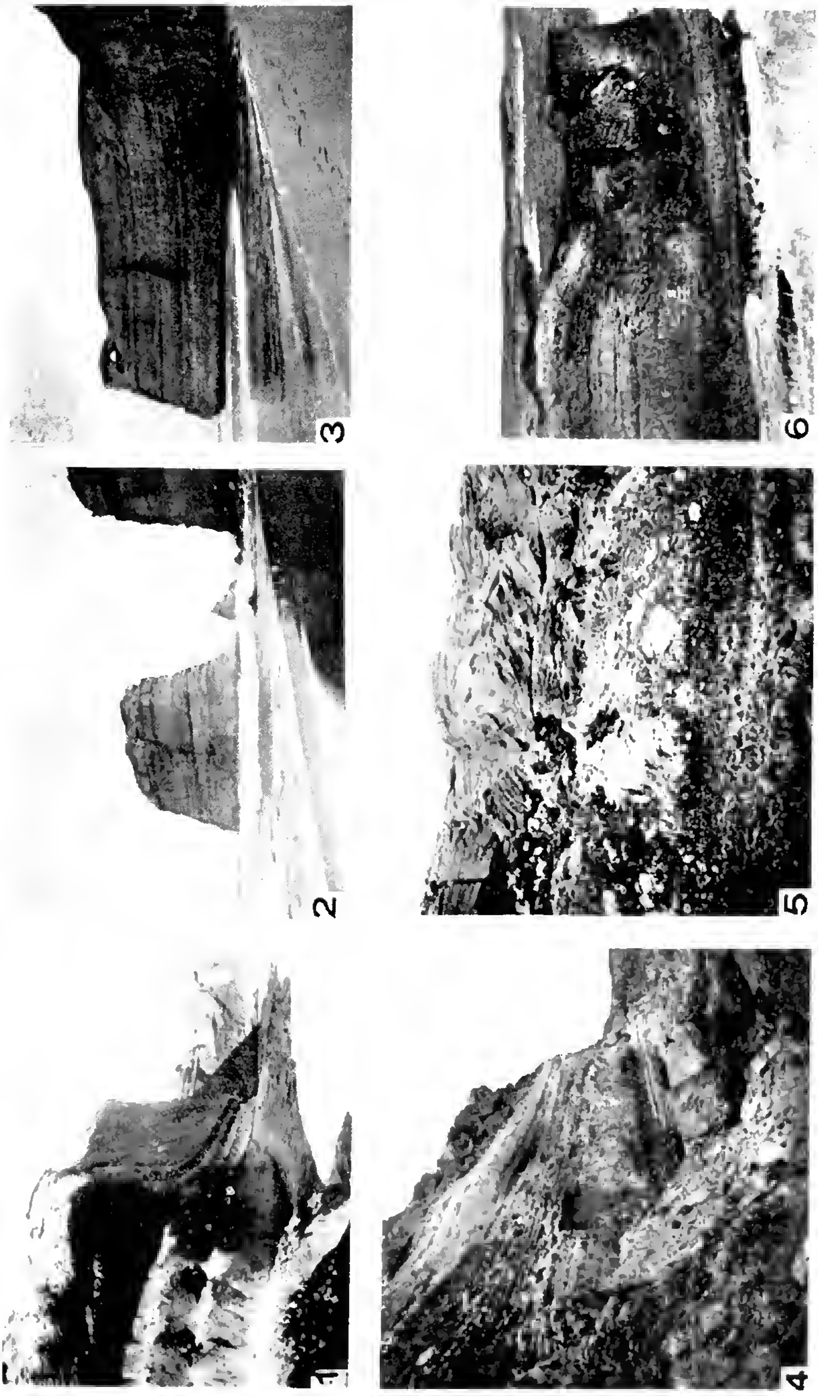
The Evidence of The Foraminifera as to The Age of The Deposits.

To sum up, it may be stated that, with the exception of Samples 1 and 2 from ½ mile north-west of the mouth of the Gellibrand River, the foraminifera in the samples examined indicate that the age of the beds from which they were collected is younger than the Janjukian and older than the Cheltenhamian. Some of the species are new, but the remainder in Samples 3 to 14 are forms which, according to the present state of our knowledge, are restricted to the Balcombian or are best represented in beds of that age. There are none of the restricted species of either the Janjukian or of the Cheltenhamian or higher beds. The larger foraminifera such as *Operculina, Amphistegina,* or *Lepidocyclina,* have not been found. *Hofkerina* and *Carpenteria,* with which they are generally associated, have, however, been met with and, as both are typically Balcombian in their occurrence, the absence of the other genera mentioned can be explained by the presence of conditions unfavorable to their existence.

Samples 1 and 2, from ½ mile north-west of Point Ronald, appear to be the oldest beds exposed, as the foraminifera include several species indicating a lower horizon than typical Balcombian. These species are referred to in the notes on the samples.

The term "Balcombian" as here used embraces the Batesfordian, as it has not been possible in the Port Campbell area to distinguish these two stages as defined by Dr. F. A. Singleton (29).

The total number of species of foraminifera recognized was 232.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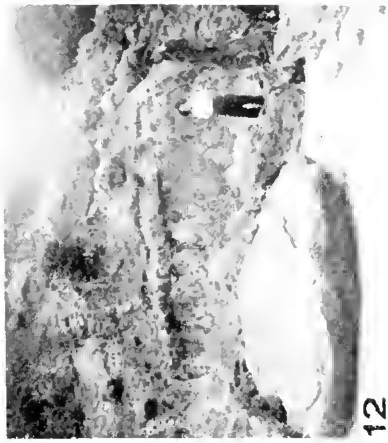

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[PROC. ROY. SOC. VICTORIA, 56 (N.S.), PT. I., 1944.]

ART VI.—*Symptoms of Copper Deficiency in Flax.*

By C. R. MILLIKAN, M.Agr.Sc.

[Read 8th August, 1943; issued separately 1st August, 1944.]

Abstract.

Wheat and flax plants in copper deficient water cultures developed severe symptoms of malnutrition. The wheat symptoms were identical with those of "reclamation disease." The flax plants showed a general chlorosis, and a somewhat rosetted appearance of the top of the plant due to shortening of the internodes. The leaves became puckered, slightly inrolled along the edges, and very twisted. Growth finally ceased, and the plants commenced to die from the top.

Introduction.

Owing to the difficulty experienced by early workers in removing small traces of copper from their nutrient solutions, the essential nature of this element for plant growth was not demonstrated until comparatively recently. Sommer (1931) was the first to show that the absence of copper in the nutrient solution resulted in a very appreciable reduction in the growth of flax, sunflowers and tomatoes; but she did not describe the symptoms manifested by the copper deficient plants.

More recently other workers, notably Brandenburg (1935), van Schreven (1936) Arnd and Hoffmann (1937), Stout and Arnon (1939) and Piper (1940, 1942) have confirmed the findings of Sommer and have described the symptoms of copper deficiency in a wide variety of plants. However, before the most recent paper of Piper, there had apparently been no description of copper deficiency symptoms in flax. In view of this in 1941 and 1942, Free Gallipoli wheat plants and Liral Crown flax plants were grown in copper deficient water cultures at the Plant Research Laboratory, Burnley, primarily with the object of determining the symptoms of copper deficiency in flax. Wheat was included in the experiment, as the symptoms of copper deficiency in cereals were well known and, their occurrence in the cultures would afford confirmation of the degree to which the copper had been eliminated from the nutrient solution.

Method.

The nutrient solution used was that of Arnon (1938), the composition of which was as follows:—

Potassium Phosphate ..	K_2HPO_4	.. 0.001 Molar
Potassium Nitrate ..	KNO_3	.. 0.006 Molar
Calcium Nitrate ..	$Ca(NO_3)_2 \cdot 4H_2O$	.. 0.004 Molar
Magnesium Sulphate ..	$MgSO_4 \cdot 7H_2O$	.. 0.002 Molar
Boron as Boric Acid ..	H_3BO_3	.. 0·5 parts per million
Manganese as Manganese Sulphate	$MnSO_4 \cdot 4H_2O$	.. 0·5 parts per million
Zinc as Zinc Sulphate ..	$ZnSO_4 \cdot 7H_2O$	.. 0·05 parts per million
Copper as Copper Sulphate	$CuSO_4 \cdot 5H_2O$	.. 0·02 parts per million
Vanadium as Ammonium Vanadate	NH_4VO_3	.. 0·01 parts per million
Chromium as Chrome Alum	$Cr_2K_2(SO_4)_4 \cdot 24H_2O$	.. 0·01 parts per million
Nickel as Nickel Sulphate	$NiSO_4 \cdot 6H_2O$	.. 0·01 parts per million
Cobalt as Cobalt Nitrate	$Co(NO_3)_2 \cdot 6H_2O$	.. 0·01 parts per million
Tungsten as Sodium Tungstate	$Na_2WO_4 \cdot 2H_2O$	.. 0·01 parts per million
Molybdenum as Ammonium Molybdate ..	$(NH_4)_2MoO_4$	.. 0·01 parts per million

An iron solution containing 0.5 per cent. $FeSO_4$ + 0.4 per cent. tartaric acid was added twice weekly at the rate of 0.6 ml. per litre of culture solution. When the plants were a few weeks old, this solution was added once a week. All these elements with the exception of copper were added to the copper deficient solutions. Every three-four weeks the old culture solutions were discarded and were replaced by fresh solution.

Molar stock solutions of the main constituents were purified by autoclaving with calcium carbonate in accordance with Stout and Arnon's (1939) modification of Steinberg's (1935) technique. After purification these stock solutions were tested by the dithizone test described by Stout and Arnon and found to contain less than 10 parts per billion of all metal impurities which react with dithizone. Double distilled water produced by pyrex glass stills was used to make up all solutions. The dithizone test indicated that this water contained approximately 1 part per billion of metal impurities. Stout and Arnon have shown that degrees of purity of the order of those outlined above are satisfactory for demonstrating copper deficiency symptoms in plants. All glassware was cleaned with 1 : 1 hydrochloric acid and rinsed with distilled water before use.

The plants were grown in two litre pyrex glass beakers blackened on the outside by a coat of gold size followed by two coats of black blackboard paint.

Plaster of Paris tops soaked in paraffin were used to cover the beakers and support the plants. The wheat and flax seeds were germinated in acid-washed sand, and were transferred to the beakers as soon as they could be conveniently handled. Four wheat and four flax plants were grown in the same beaker.

Results.

The following are the symptoms of copper deficiency which developed:—

WHEAT.

The first symptoms of copper deficiency appeared approximately three to four weeks after setting up the cultures. The plants were not as tall as the controls, a slight, general chlorosis became evident, and the youngest leaves were slow in unrolling The tips and distal edges of subsequently-formed leaves became markedly chlorotic and soon withered and died without unrolling (Pl. IV. fig. 1). While some secondary tillers were produced, the plants made very little further growth, with the result that no elongation or head formation occurred. The final height of the plants was approximately one foot, while the plants growing in the complete solution were over four feet high at the end of the experiment (Pl. IV. fig. 2). With the addition of small amounts of copper to wheat and oats growing in water cultures, Piper (1940, 1942) has shown that sterile heads may be produced. It was evident that the symptoms exhibited by the wheat plants growing in the copper deficient solutions were identical with those of "reclamation disease" described by other workers.

FLAX.

The flax plants grew normally for approximately four weeks, after which time growth became very retarded. The internodes between leaves produced subsequently were short, giving the top of the plant a somewhat rosetted appearance. These new leaves were much smaller than the controls and noticeably paler green in color than normal. They became puckered, slightly in-rolled along the edges, and very twisted (Pl. IV., fig. 3). The stems of the plants also showed some twisting. Later the leaves in the middle portion of the stem developed a dark, greyish-green, semi-transparent discolouration at the tips. These leaves soon drooped and withered and died from the tips downwards. The lowest leaves, on the other hand, remained apparently normal. Meanwhile, secondary shoots were sent out from the bottom, but soon became chlorotic with small twisted leaves. Finally growth ceased and the plants commenced to die from the tops.

Sommer (1931) and Piper (1942) have shown that, in the absence of copper, flax plants make very restricted growth. The symptoms of copper deficiency in flax, described by Piper, are similar to those set out above, with the exception that no twisting of the leaves was reported.

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Description of Plate.

PLATE IV.

Fig. 1. Wheat leaves showing "wither tip" and inrolling characteristic of copper deficiency.

Fig. 2. Water culture experiment with wheat and flax, showing the marked reduction in growth resulting from a deficiency of copper.

Fig. 3. Copper deficiency symptoms in flax. Left: Control. Right: Copper deficient plant showing marked reduction in growth, general chlorosis, and inrolling and twisting of leaves.

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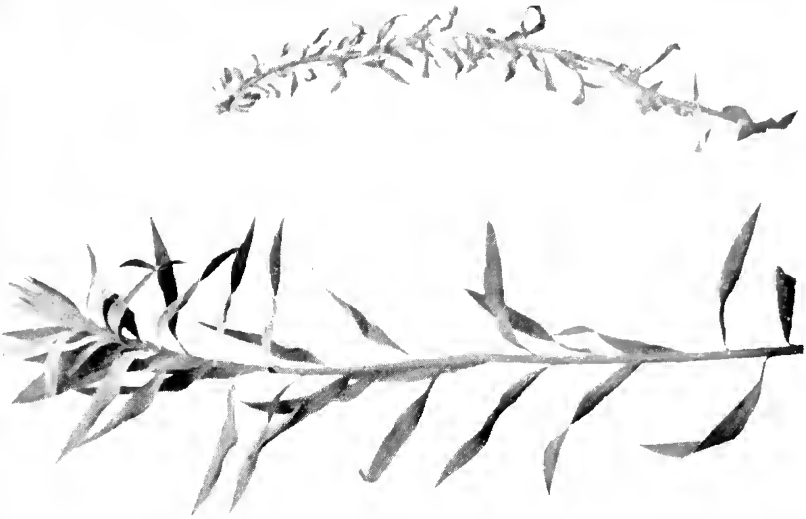

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[Proc. Roy. Soc. Victoria, 56 (N.S.), Pt. II., 1945.]

Art VII.—*Records of Plant Remains from the Upper Silurian and Early Devonian Rocks of Victoria.*

By ISABEL C. COOKSON, D.Sc.

[Read 11th November, 1943; issued separately 30th June, 1945.]

In the period that has elapsed since 1935 when my last paper on Victorian Palaeozoic plants was published, further collections have been made from several hitherto unknown localities in the same stratigraphical series. These specimens were put aside pending the discovery of further examples which, it was hoped, might give more detailed information regarding the morphology of our early plant types. However, in order to facilitate the work of geologists interested in Palaeozoic stratigraphy, it has been suggested that the genera found at these new localities should be put on record now. This is therefore done below and for the sake of completeness, lists of plant remains from previously recorded outcrops are included. The botanical discussion of morphological details is being left until a later time.

Owing to the incompleteness of some specimens, a final determination cannot be made. The letters cf. before a species name denotes that the fossils are most likely referable to the species given.

I am indebted to Mr. W. Baragwanath and Rev. E. D. Gill, B.A., B.D., for information regarding some of the localities mentioned.

Yea—Alexandra District.

Killingworth-road, Yea. ¼ mile from Yea to Molesworth-road. Geol. Surv. loc. 14 (10, 5).

Baragwanathia longifolia.

cf. *Hostimella* sp.

Brackley's Cutting, Yea, to Cheviot-road, south of turn off Yea to Mansfield-road. Geol. Surv. loc. 4 (4, 5).

Baragwanathia longifolia.

Gobur, near allotments 9 and 10, east of township site. Geol. Surv. loc. 19 (5).

Baragwanathia longifolia.

Railway cutting, near Alexandra, between 99¼ and 99½ miles from Melbourne. Geol. Surv. loc. 9 (5, 10).

Baragwanathia longifolia.

First railway cutting out of Alexandra railway station. Geol. Surv. loc. 5 (5, 10).

Baragwanathia longifolia.

Mount Pleasant, $1\frac{1}{4}$ miles from Alexandra on the old road to Thornton (1).

Pachytheca sp.
Zosterophyllum australianum.
cf. *Hostimella* sp.
Hedeia corymbosa.
cf. *Yarravia.*
cf. *Baragwanathia longifolia.*
"*Pinnately branched axes*".
"*Stems with small spirally arranged elevations*".
"*Circinately coiled tips*".

Hall's Flat-road—cutting on road from Alexandra to Hall's Flat, about one mile from the former (1).

Zosterophyllum australianum.
"*Pinnately branched axes*".

GAFFNEY'S CREEK—WOOD'S POINT DISTRICT.

Gaffney's Creek, road cutting near Police station (8).

cf. *Hostimella* sp.

Wood's Point, road to Comet Mine (9).

Zosterophyllum australianum.
cf. *Hostimella* sp.
"*Stems with small spirally arranged elevations or depressions*" (9) cf. Mt. Pleasant, Alexandra (1).

Indeterminate plant fragments have been collected from outcrops on the road from Gaffney's Creek to Wood's Point.

ENOCH'S POINT DISTRICT (6).

Cable's Creek, a western tributary of Big River south-west of Enoch's Point.

Baragwanathia longifolia (6, 8).

Enoch's Creek, east of township of Enoch's Point (6).

Baragwanathia longifolia.

WOOD'S POINT—WARBURTON DISTRICT.

Quarry on Yarra Track, about 20 miles east of "McVeighs" (3).

Baragwanathia longifolia.

Quarry on Yarra Track, about 19 miles east of "McVeighs" (10, 4, 3).

Baragwanathia longifolia.
Yarravia oblonga.
Yarravia subsphaerica.
cf. *Hostimella* sp.

Quarry on Yarra Track, about 18 miles east of "McVeighs" (3).

Zosterophyllum australianum.
cf. *Hedeia corymbosa.*
cf. *Hostimella* sp.

Quarry on Yarra Track, 10½ miles east of "McVeighs" (3).

Zosterophyllum australianum.

Road cutting on Warburton-Wood's Point-road, about 16½ miles east of Warburton and adjacent to Yankee Jim's Creek (3).

Pachytheca sp.
Zosterophyllum australianum.
Hostimella sp.
"*Pinnately branched axes*" cf. Mt. Pleasant, Alexandra (1).
"*Stems with small spirally arranged elevations or depressions*". cf. Mt. Pleasant (1).

Indeterminate plant fragments occur at several localities between McVeigh's and McMahon's Creek, 11½ miles east of Warburton.

LILYDALE DISTRICT.

Hull-road, Parish of Mooroolbark, 14 chains south of its junction with the main Melbourne-Lilydale-road. Gill's loc. 1 (2).

Sporogonites Chapmani.
Yarravia cf. *oblonga.*
Zosterophyllum australianum.
cf. *Hedeia corymbosa.*
cf. *Hostimella* sp.

Killara, Syme's Homestead (*vide* Gill, same volume).

cf. *Hedeia corymbosa.*

In adjacent quarries called Syme's Tunnel and Syme's Quarry indeterminate plant fragments occur.

WALHALLA DISTRICT.

Knott railway cutting below bridge (9).

Hostimella sp.

Thomson River—"Jordan River Beds" (11, loc. 1, 10).

Baragwanathia longifolia.
cf. *Hostimella* sp.

Walhalla—Centennial Beds.

Loc. 1, about half a mile up east branch of Stringer's Creek (9).
Sporogonites Chapmani f. minor.
Loc. 2, North-road Quarry, about 1 mile north of Walhalla on Walhalla-Aberfeldy-road (9).
Hostimella sp.
Zosterophyllum australianum.
Sporogonites Chapmani.
Pachytheca sp. (1).

Plant remains have been recorded also from Platina (8, 11, loc. 2), and by Thomas from Gould (4) and from cuttings on the Telbit-road (12).

South Gippsland.

Silurian inlier, Parish of Kongwak, occupying allotments 15A, 15, 16, 12c, indeterminate plant fragments have been recorded as *Haliserites dechenianus* (7, 8).

Rhyll, Philip Island, No. 1 Bore, 327-350 feet.

cf. *Thursophyton* (8).

Livingstone Creek, between Cape Liptrap and Waratah Bay (8).

cf. *Hostimella* sp.

"*Circinately coiled stem tip*". cf. Mt. Pleasant (1).

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[PROC. ROY. SOC. VICTORIA, 56 (N.S.), PT. II., 1945.]

ART. VIII.—*Note on Cretaceous Strata in the Purari Valley, Papua.*

By S. WARREN CAREY, D.Sc.

(Published by permission of the Directors of the Australasian Petroleum Company.)

[Read 11th November, 1943: issued separately 30th June, 1945.]

The phragmacone of a belemnite was found in the upper Purari Valley in January, 1894, by Sir William MacGregor, (1). No further geological observations were made in that area until 1940 when Cretaceous strata were found by the present writer. It now appears that there are extensive outcrops of Mesozoic rocks in the area between Hathor Gorge and the Paw Valley, which lies some 15 miles east of the gorge on the left bank of the Purari. To date, only four field days have been spent on these exposures, so that our knowledge of the structure and succession is still rather rudimentary. The available data concerning these rocks are presented on a plan of the Paw Creek area (fig. 1).

Four straight sections have been measured, all within the same stratigraphic interval of about 6,000 feet. There is no direct evidence of fault repetition in this thickness, but some anomalous dips and disturbed strata have been noted and the examination has not been sufficiently thorough to deny the possibility of some faulting which might affect the observed thickness. However, a thickness of over 5,000 feet is found both in Sisa Creek and in the Paw Creek sections, and it is unlikely that detailed mapping would reduce the outcropping thickness of Lower Cretaceous strata to less than 5,000 feet, with the base still not exposed.

The sequence consists of massive or thick-bedded sandstones, and dark thin-bedded mudstones. The sandstones are dark-coloured and very hard, and in the field were thought to be tuffaceous, and described as greywackes. A typical sample (112) was examined in thin section, and found to consist almost entirely of materials of volcanic origin, not noticeably worn. The slide consists largely of plagioclase in subeuhedral forms. Quartz is present in angular grains, but it is quite subordinate to the plagioclase. Magnetite is common and apatite in small crystals is

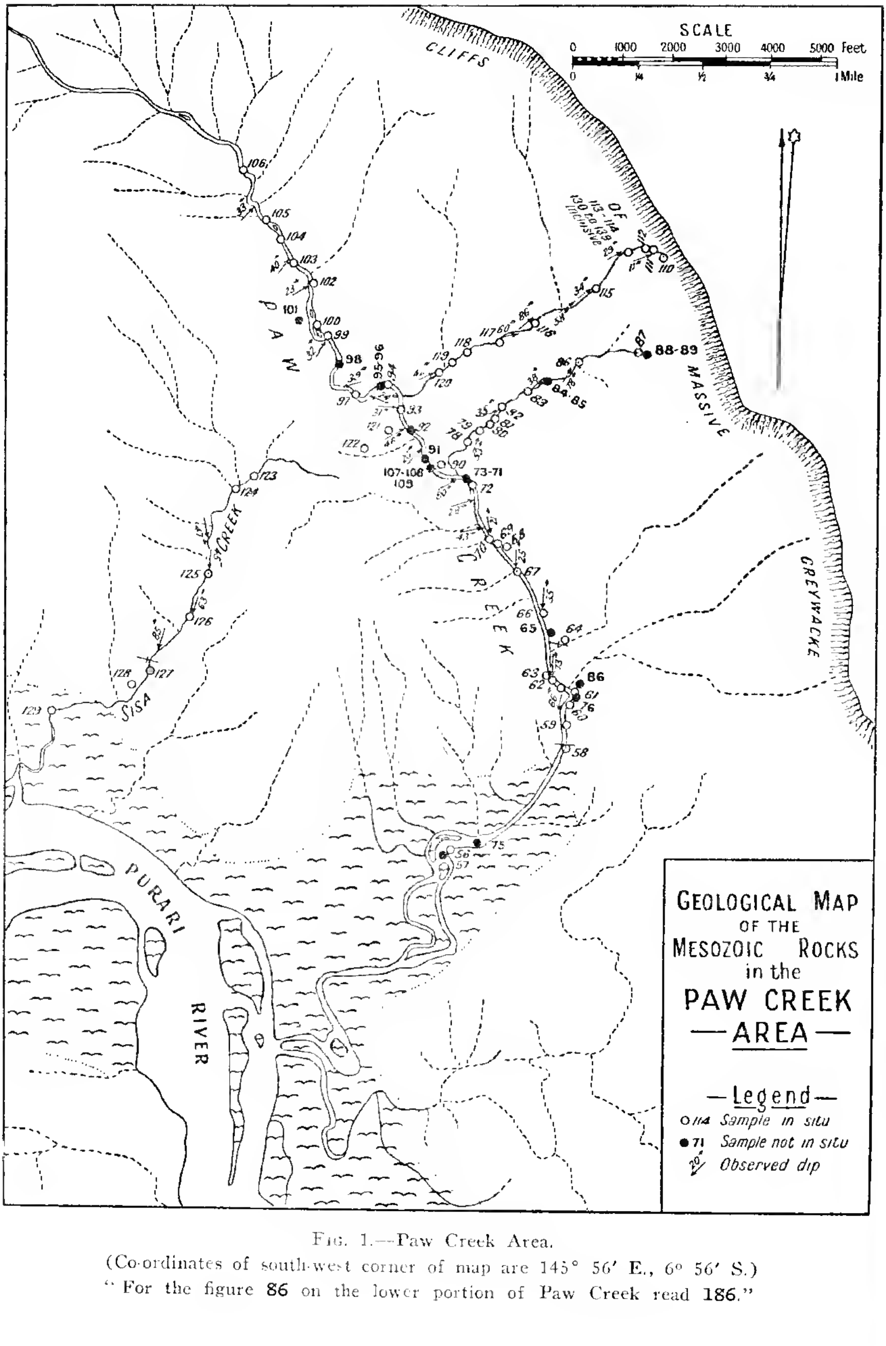

Fig. 1.—Paw Creek Area.
(Co-ordinates of south-west corner of map are 145° 56′ E., 6° 56′ S.)
" For the figure 86 on the lower portion of Paw Creek read 186."

present. There is a good deal of interstitial chlorite with epidote, but no real groundmass. Former ferro-magnesian minerals are represented mainly by their decomposition products, but a few ragged pieces of hornblende are present.

The sandstones are usually unfossiliferous, but one richly fossiliferous horizon was found packed with molluscan material. This horizon has been called the *Exogyra* bed. It is not more than 10 feet thick. Associated with it are thin bands of biscuity shales with indeterminate plant remains. The *Exogyra* bed has only been found along the north-east side of Paw Creek Valley about 1,000 feet from the top of the cliffs, which indirect evidence suggests may be capped with Eocene *Lacazina* limestone.

A meagre fauna of foraminifera and ostracoda and echinoid spines was found in the mudstones by Dr. Glaessner (2). He also reports that the *Exogyra* bed contains *Exogyra* cf. *couloni*, *Ostrea*, and a gastropod and a pelecypod not determinable on the samples available. Both assemblages are determined by him as of Aptian-Albian age.

Overlying the Cretaceous rocks are lower Tertiary strata which in different sections rest on different horizons of the Cretaceous beds. Thus on the north-east side of Paw Creek 3,700 feet of dominantly arenaceous strata with the *Exogyra* bed about 1,000 feet from the top, are present below the Eocene. On Sisa Creek only 2,600 feet of arenaceous beds are present beneath the *Lacazina* limestone, and the *Exogyra* bed is not present. On the lower part of Paw Creek itself, only 1,100 feet of the arenaceous beds are present followed by limestone. Again the *Exogyra* bed is missing. In Noakes's Chimbu section (4) on the other hand, the stratigraphic equivalents of these Paw Creek beds, including the molluscan bed, are followed by a considerable development of Cenomanian strata, before the *Lacazina* limestone is reached. While some of these relationships are possibly complicated by faulting, it is difficult to escape the conclusion that a strong erosion interval amounting probably to angular unconformity separated the Cretaceous and Eocene in the Purari area. No angular unconformity has so far been observed in the field.

Paw Valley Samples not *in situ*:

The material collected not *in situ* in the Paw Valley, falls into six categories:

(1) Material definitely derived from the *Exogyra* bed (samples 84, 85, 88, 89).—These samples occur in a scree slope at the foot of a cliff in which the *Exogyra* bed is known to outcrop, and they are identical in lithology and fauna. They need no further comment.

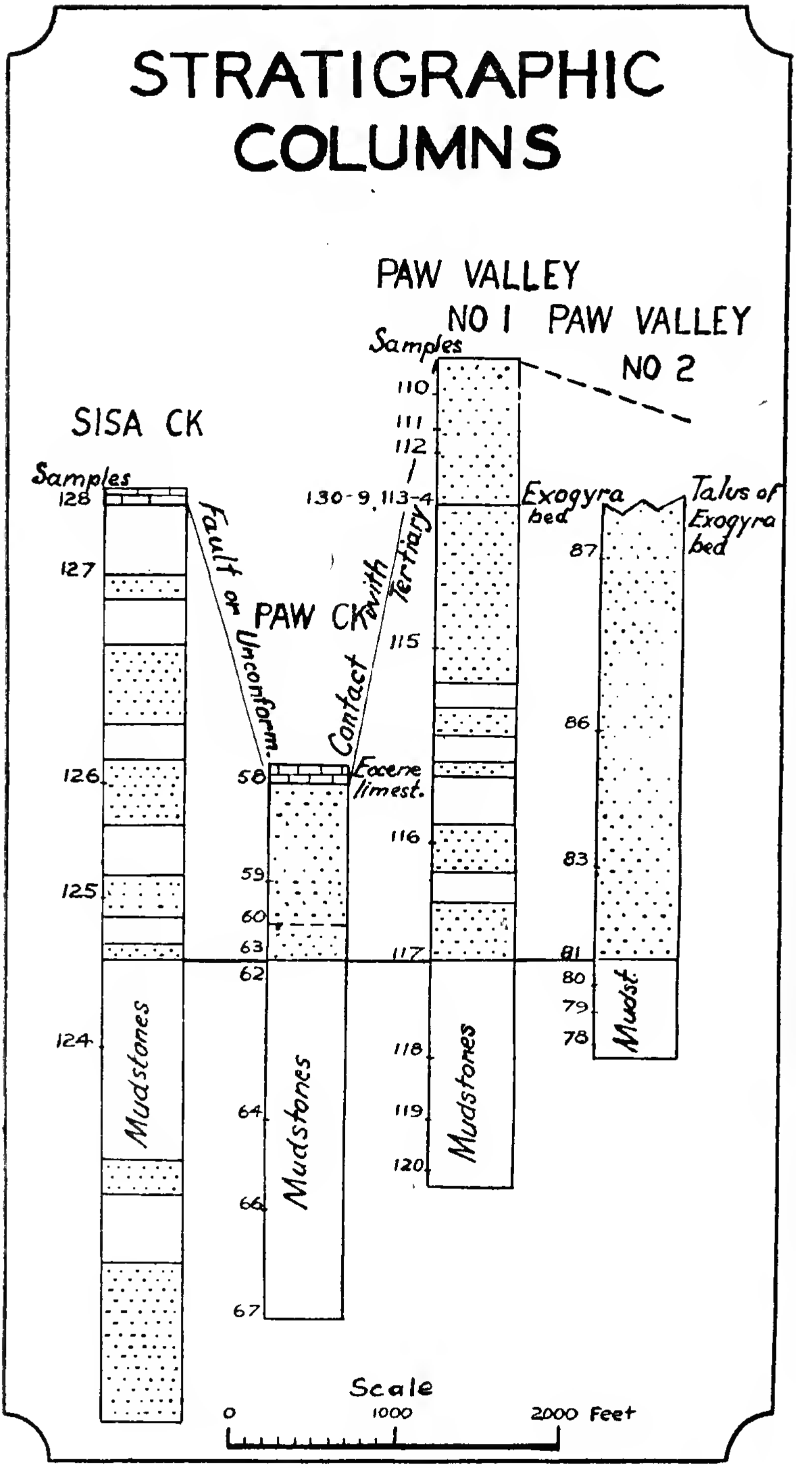

FIG. 2.—Paw Creek Area.

(2) Belemnite-bearing sandstone (sample 186).—A large belemnite was found in an otherwise barren sandstone block in the Paw Creek bed (for locality see map). It could not have travelled far for the belemnite was quite loosely attached to the sandstone. The belemnite was determined by Dr. Whitehouse as *Tetrabelus* n.sp. It is now described by Dr. Glaessner as *Tetrabelus macgregori* after the distinguished pioneer who half a century ago first recorded the presence of belemnites and Mesozoic strata in this part of New Guinea.

There is no reason to believe that the belemnite belongs to the *Exogyra* bed itself; it seems more probable that it was derived from one of the sandstones which are not generally fossiliferous. Near where the belemnite was found a molluscan sandstone was found (sample 61), carrying large numbers of an oval pelecypod referred by Glaessner to the genus *Pseudavicula*. This has a different lithology from the *Exogyra* bed, and the rest of the loose boulders, though the genus is present in other samples. Like No. 186, this sample is soft and little abraded and does not appear to have travelled far.

(3) Plant-bearing material (samples 75, 76).—A couple of well-worn pebbles of biscuity shale containing plant remains were found in the bed of Paw Creek. Their source is apparently somewhere among the strata in the Paw Valley, which as far as is known, are all Cretaceous, except perhaps a capping of Eocene limestone on top of the range overlooking it on the north-east. Plant-bearing beds of not very different lithology were found *in situ* in close association with the *Exogyra* bed, but the plant remains there were very broken with no recognizable pinnules. Samples 75 and 76 were sent to Dr. A. B. Walkom, who reported that they are "too fragmentary for very accurate determination. They represent portions of pinnae, usually with several elongated, somewhat wedge-shaped pinnules with venation of a general sphenopteroid type. Thus they belong to a species of the form-genus *Sphenopteris*. Of the species known to me (Walkom) as occurring in Australia, the Purari River specimens show some resemblance to *Sphenopteris erecta* (Tenison-Woods) which has been figured (Queensland Geological Survey, Publication 263, Plate 5, figs. 4 and 5) from the Burrum series of Queensland. The Burrum series is of Cretaceous age. . . ."

(4) *Lacazina* limestone (samples 56, 73, 74, 128).—Two specimens were collected from boulders of *Lacazina* limestone in the bed of Paw Creek about 4 miles from the mouth. They are both from fairly large though well-worn boulders, and occur in an area believed to be entirely Mesozoic. The only reasonable interpretation of their occurrence seems to be that the Eocene limestone must cap the range on the north-east side of the valley at least in some parts, and that the material has fallen and been

transported down the mountain side to the stream bed. If this interpretation is correct, the nearest possible point of origin is over a mile away, and 2,000 feet or more above.

(5) Cone-in-cone structure (sample 92).—In several places in the Paw Valley pieces of hard shaley rock were found showing well developed cone-in-cone structure. This has apparently been derived from the Cretaceous strata, but was not observed *in situ*.

(6) Molluscan calcareous sandstone (samples 57, 65, 75, 77, 91, 98, 101, 107, 108, 109, 140).—At several points on the floor of the valley both near the head and near the mouth a large number of well-worn blocks of hard calcareous sandstone packed with fossils was found. These have a different lithology from the *Exogyra* bed, which is softer and much less limy, and there is no definite reason to assume that they belong to the same horizon. However, no blocks of this material were found in either of the tributary creeks where the *Exogyra* bed is known to outcrop. It may be, however, that the *Exogyra* bed is a facies of the same bed as yielded the other samples, and that it is for this reason that the calcareous type was not found in the section or creeks containing the *Exogyra* bed. In any case, the horizon of the Molluscan material cannot be very different from that of the *Exogyra* bed. There is a fair amount of variation between the many blocks of this group. A fine-grained type is packed with small gastropods, and approaches in character towards a hard blue limestone. Other types have more pelecypods. Another type is quite pebbly. According to Glaessner, the pebbles consist of hard grey marl, red and dark cherts, quartz, &c., and some phosphatic nodules.

The following molluscs have been determined by Dr. Glaessner from these samples.—*Trigonia, Cardium, Ptychomya, Pseudavicula, Ostrea, Mytilus, Alaria, Nerinea,* and *Tetrabelus macgregori.* Several other genera are present, but not sufficiently well preserved to be determined.

These molluscan beds are of considerable interest because the rock is hard and water-worn boulders of it have a characteristic conspicuous lithology which draws the attention even of the non-geologist passing it in the stream, with the result that it has been found over a large tract of country. If the doubtful cases are included it extends from near Kerema across the middle Purari to the Waghi Valley, and westwards as far as the Strickland.

(*a*) Numerous samples (15–26 inclusive, and 33) of these molluscan beds were collected by the writer in the bed of Wabo Creek. The lithology is identical with the Paw Creek material. Here it is associated with numerous large blocks of silicified wood, some of them a foot or so in diameter (sample 26F). The

molluscan beds were not found *in situ* for the section examined by the writer there did not reach them, but it was clear from structural relationships that the molluscan material must be derived from an horizon not very far below the Eocene limestone.

(*b*) Several samples were found in the Wheian Valley by the writer in 1939 (samples 69A–69F). Here again the structure is such that it is apparent that the molluscan beds cannot be very far below the lowest Tertiary beds. At the base of a section measured between the Wheian and Pio rivers, oyster bearing beds were found *in situ*, though not well preserved. These are about 400 feet below the base of the Tertiary strata. In this case it was only after comparison with samples from Paw Creek that the Cretaceous age could be inferred.

(*c*) Sample 144 collected in Hathor Gorge by the writer, and a sample collected by Patrol Officer Ethell a few miles south-west of Lake Tebera, also have this characteristic lithology.

(*d*) Further afield it is interesting to note that E. R. Stanley's description (3) of "dark calcareous sandstones and bluish-grey limestones containing *Orbitolites*, *Gryphaea*, *Modiola*, *Aviculopecten*, and *Belemnites*" at the "head of Karova Creek", fits very well with the lithology and facies of these other Cretaceous rocks, though subsequent work has thrown doubt on the authenticity of Stanley's locality.

(*e*) Dr. Glaessner states that a pebble of bluish-green sandstone containing abundant molluscan shells was collected by G. Barrow on the Strickland River. This pebble resembles the molluscan beds in Paw Creek. Glaessner also correlates these molluscan beds with the top of Noakes' "stage 2" in the Chimbu Valley section (4). Furthermore a fossiliferous rock corresponding closely to the Paw Creek molluscan beds was found by Mr. Vial, Patrol Officer, about 3 miles east of Mingenda.

Thus, these molluscan beds are likely to prove of great value in the correlation of the Cretaceous strata throughout a wide province. Evidence suggests that the richly fossiliferous material is confined to a narrow zone near the top of a thick section of sparsely fossiliferous sandstones and shales. Being resistant to erosion by virtue of its extra lime content, and the fossils being very conspicuous on waterworn surfaces, boulders derived from this narrow zone have been found and recorded over a wide area.

THE PURARI FORMATION:

A. Gibb Maitland has referred to the belemnite bearing strata recorded by Sir William MacGregor as the Purari beds (5). So far as the writer is aware the term "Purari beds," or "Purari formation" has not been used in any other sense in any published record. Hence it is proposed that this term be adopted.

The Purari formation as now defined is a sequence of marine mudstones and sandstones, with a thin zone near the top rich in lamellibranchs, gastropods, and occasional belemnites, which outcrops in the middle and upper Purari Valley. Its fauna is described by Glaessner, and determined by him as belonging to the upper part of the Lower Cretaceous. Its thickness has been proved to exceed 5,000 feet, but neither the base nor the top is as yet precisely determined. Fragmentary data suggest that the formation may be identifiable over a region embracing the upper Strickland Valley, Chimbu, the upper and middle Purari Valley, and possibly the hinterland of Kerema. The molluscan zone is a characteristic marker of this formation.

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Art. IX.—*The Mesozoic Stratigraphy of the Fly River Headwaters, Papua.*

By N. OSBORNE.

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Abstract.

The headwaters of the Fly River, known to the local natives as Wok Feneng, expose a thick section of Mesozoic sediments in a south dipping monocline on the rugged southern fall of the Central Highlands of New Guinea. These underlie, without apparent angular discordance, the Tertiary limestones supporting the rough mountain ranges or "Limestone Barrier" along the foot of the Central Highlands in western Papua.

The Mesozoic section totalling nearly 7,500 feet of marine sediments is divided on lithological grounds into two distinct units of sedimentation, each dominantly argillaceous at the top and arenaceous at the bottom. These two units have been named Feing and Kuabgen groups respectively. Both are fossiliferous and an examination of the fossils by Dr. M. F. Glaessner establishes the age of the Feing group as Cretaceous (Cenomanian-Albian) and of the Kuabgen group as Upper Jurassic.

The character of the basal Kuabgen rocks suggests a derivation from granitic basement which probably underlies them at no great depth. The time break between the Kuabgen and Feing groups, together with the composition of the basal Feing deposits suggests an Albian transgression over the uppermost Jurassic. An important unconformity is indicated also between the Feing group and the Tertiary limestones by another big time break and a sudden and complete change in lithology.

Introduction.

The object of this paper is to describe the occurrence of Mesozoic sediments in the headwaters area of the Fly River, referred to hereafter as the Feneng area, to give an account of the section exposed and to indicate its significance in respect to the Mesozoic geological history of New Guinea.

The Fly River rises in the Central Highlands of New Guinea in Papuan territory about 40 miles from the boundary with Netherlands New Guinea and very close to the Mandated Territory border. The main headwaters stream is called by the local natives, Wok Feneng, Wok being the native word for water. The principal tributaries of the Fly are the Alice River (Ok Tedi) to the west and the Palmer and Strickland Rivers to the east.

In this area a series of extremely rough precipitous limestone mountains rises along the foot of the Central Highlands, to be breached in deep narrow gorges by the Fly River and many of its larger tributaries. This "Limestone Barrier" has presented a formidable obstacle to exploration of the main divide.

Karius and Champion (1929) were the first to negotiate these limestones when they crossed the Central Highlands from the Fly to the Sepik River in 1927-8 but they made no observations of stratigraphic value.

Earlier explorations failed to penetrate the Limestone Barrier, but samples collected from the upper Alice River by Austin (1923) and examined by Chapman (1925), and from the Wai Mungi (1924-5), indicated the limestones to be of Tertiary age; while Everill in 1884 found in the Strickland River or one of its tributaries at a point which has since eluded identification, fossils recognized by Wilkinson (1888) to be Cretaceous. [Further study by Dr. Glaessner and writer of Everill's record and comparison of his map with the recently compiled air photographic maps of Island Exploration Coy. indicate that the farthest point reached by his expedition was in the main Strickland River some 3-4 miles below the junction with the Murray River. The locality referred to by Wilkinson as the source of the Cretaceous fossils he identified, is now recognized as one in which very fossiliferous late Tertiary rocks outcrop, indicating that the Cretaceous specimens were not found in situ.]

Downstream from the outcropping limestones Everill also found waterworn pebbles containing ammonites determined by Etheridge (1890) to be Jurassic in age. Probably based on this discovery, Stanley (1923) and later David (1932) show on their maps a patch of Jurassic on this river around latitude 6-7° south. Field investigations by geologists attached to Island Exploration Company 1938-9 have shown that no Mesozoic rocks outcrop south of the Limestone Barrier and that the pebbles found by Everill must have been brought down by the swiftly flowing waters from some locality considerably further upstream. Likewise incorrect are the Mesozoic outcrops shown to occur on the Palmer River below its confluence with the Tully River, extending across to the Fly, and based apparently on stream pebbles picked up by Sir William McGregor and determined by Gregory and Trench (1916).

In 1937 a gold prospecting expedition headed by Ward Williams investigated some of the Fly, Strickland, and Sepik headwaters, and in the upper Om River one of the headstreams of the Strickland, they discovered "black shales studded with magnificent ammonites."—Campbell (1938). Specimens of these ammonites handed to Dr. W. Chawner of Island Exploration Coy. were sent to Dr. Reeside of the U.S. Geological Survey who reported (personal communication) that they are Perisphinctids, indicative of an upper Jurassic or lower Cretaceous age. W. Korn, J. Burke, and W. Kienzle, members of the expedition travelled overland to the Central Highlands by way of the Fly River route and the Wok Kup but have not made available any maps or notes of their journey.

Geologists of Island Exploration Coy. investigating the petroleum possibilities of the Fly River region also found the limestone mountains a serious obstacle to the exploration required to complete the stratigraphic section. Air reconnaissance had shown that the limestone belt was succeeded to the north by an entirely different terrain and that in the main Fly River headwaters (Wok Feneng) and Strickland valley at least, south dipping monoclinal conditions of considerable extent gave promise that good sections of the pre-limestone strata might be exposed there.

Since transport in this remote and mountainous country was confined to native carriers, the difficulty in keeping geological parties beyond the Limestone Barrier supplied sufficiently to remain out long enough to perform useful work was one that could be solved only by the introduction of air transport. Consequently it was decided to send specially equipped expeditions into the upper reaches of both the Fly and Strickland Rivers, and to supply them with foodstuffs by dropping from the air at their most forward bases. It was decided also to send an expedition into the Upper Palmer River although the geology appeared from the air to be complicated by faulting. Here, however, the Limestone Barrrier is not so strongly developed and it is possible to employ native canoes for transport much closer to the area to be examined, thus obviating the necessity for air transport the success of which depends on clear weather, a condition not frequently fulfilled in this country. The months of December and January were chosen as the period of the year most likely to provide good weather.

The upper Palmer expedition was made in October-November, 1938, under the leadership of Dr. W. Chawner with W. D. Mott as assistant geologist. They measured and described some 3,450 feet of section which they considered unconformably underlies the Tertiary limestone, the upper part of the section being predominantly argillaceous, the lower arenaceous. The contained fossils were examined by Dr. M. F. Glaessner, company palaeontologist, who regarded them as indicating a Cretaceous (Cenomanian-Albian) age.

The Strickland expedition under G. Barrow, December, 1938, and January, 1939, ascended that river with great difficulty to a point some 16 miles above Murray Junction without getting out of Tertiary strata and was prevented by supply troubles from penetrating further.

The Wok Feneng Expedition.

The upper Fly expedition, known as the Wok Feneng Expedition, led by the author with the late G. Sadler, assistant geologist, E. Ross and R. Ely, field assistants, and 70 Papuan natives,

started November 27th, 1938, from a base on the Palmer River, 12 miles above its junction with the Fly River and the limit of water transport convenient to the expedition. The author had made an air reconnaissance with Dr. Washington Gray a few days previously with the object principally of selecting a suitable locality for establishing a base beyond the Limestone Barrier for dropping supplies.

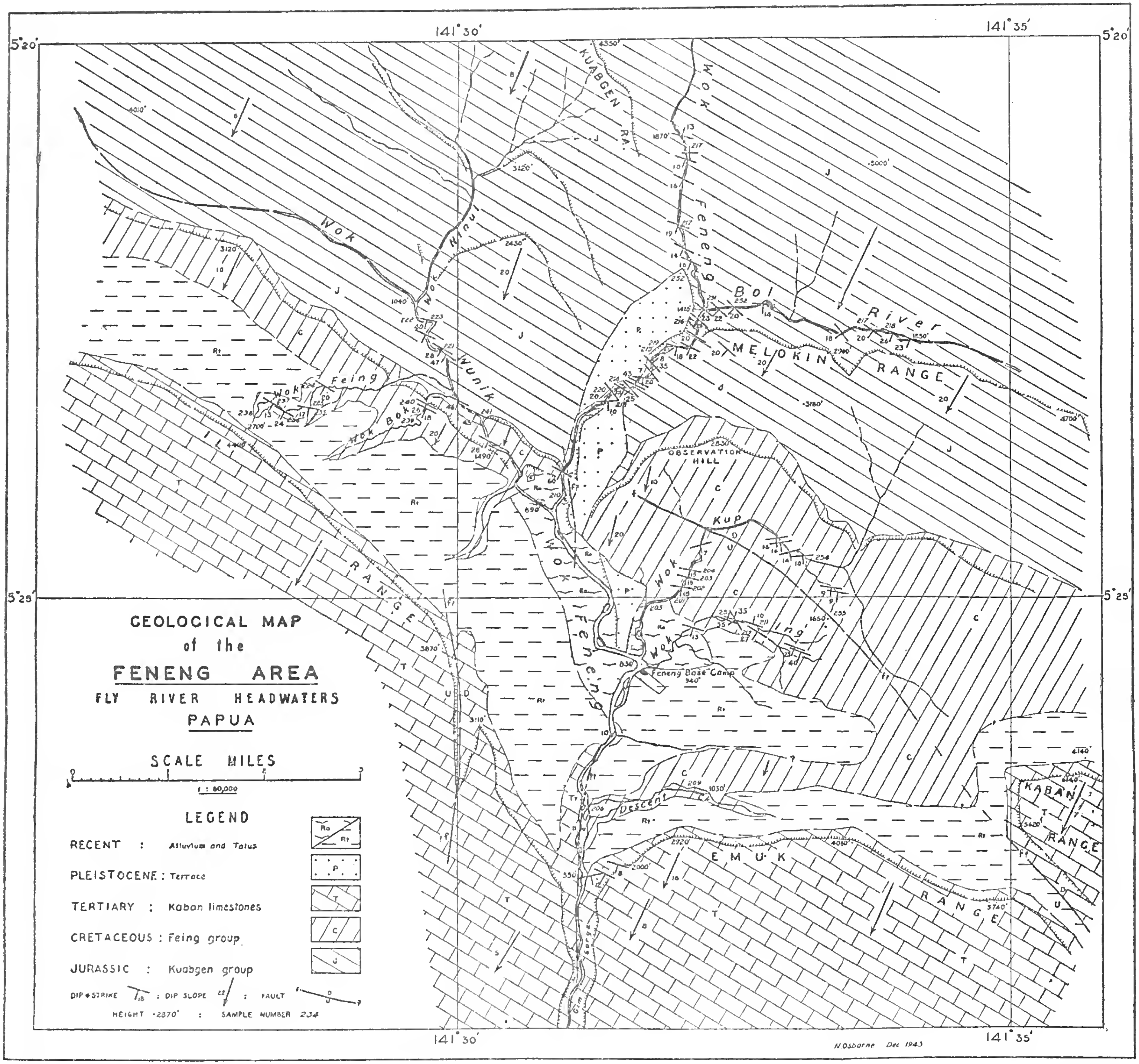
There is no native track across the limestones here and the route followed was roughly that taken by Korn, Burke, and Kienzle along the lip of the Fly River gorge on the east side.

The selected dropping base on the Wok Feneng at its junction with the Wok Kup and Wok Ing was reached December 16th, the journey of 30 miles taking 20 days, adequate testimony to the difficult nature of the country which makes it necessary to relay supplies and equipment in short stages. Base camp was established here and all labour set to work immediately to cut a clearing in the jungle for dropping supplies. This was the Feneng Base Camp.

On arrival the party had enough food to allow the supply aeroplane seven days' grace on its scheduled date of arrival—December 22nd—and then in case of failure, enough to make a five days' return to the forward base on the south side of the Limestone Barrier. Fortunately the weather was fine December 23rd and 24th, and enough food was dropped and recovered to give the party a total of six weeks in the Feneng area.

Except for a small scale air sketch map by Campbell (*ibid.*) and the journey of Korn, Burke, and Kienzle, about which there was no record, the Feneng area was previously quite unexplored and unmapped. The party therefore had to make its own topographic as well as geological survey. It had been intended originally to fix the position of the Feneng Base Camp by astronomic observation using a theodolite and wireless time. However the portable radio set went out of commission before reaching the Feneng area so instead, careful bearings were taken to prominent peaks on the Il and Emuk Ranges, which were likely to be visible both from the Feneng area and from the south side at points whose positions were known accurately. With these and a latitude determination, the Feneng Base was fixed with reasonable accuracy. A base line was laid down in the clearing and from it a triangulation net was made of all other outstanding features visible. Individual traverses were then made by pace and compass methods using aneroid and hand level for heights.

A few traverses were made by Sadler and the author working together, but most of the exploration was carried out by each geologist working separately with his own carrying line in expeditions lasting up to eight days away from base.


GEOLOGICAL MAP
of the
FENENG AREA
FLY RIVER HEADWATERS
PAPUA
SCALE MILES
1 : 80,000
LEGEND
RECENT : Alluvium and Talus
PLEISTOCENE : Terrace
TERTIARY : Kaban limestones
CRETACEOUS : Feing group
JURASSIC : Kuabgen group
DIP + STRIKE : DIP SLOPE : FAULT
HEIGHT ·2370' : SAMPLE NUMBER 234
141°30'
141°35'
5°20'
5°25'
KUABGEN RA.
Wok Feneng
Wok Nuk
Wok Wunik
Wok Feing
Wok Bok
Bol River
MELOKIN RANGE
OBSERVATION HILL
Wok Kup
Wok Ing
Feneng Base Camp
Descent
EMUK RANGE
KABAN RANGE
Gim Gorge
N. Osborne Dec 1943

The party left the Feneng area January 27th, arriving back at the forward base on the south side of the Limestone Barrier January 30th, 1939.

ACKNOWLEDGMENTS.

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Physiography.

The area covered by this paper is that part of the southern slopes of the Central Highlands of New Guinea occupied by the headwaters of the Fly River. It is a region of sharp relief and mostly high elevation.

The Limestone Barrier rearing conspicuously along the foot of the Central Highlands in this area is divided into three sections, called from west to east, Il, Emuk, and Kaban Ranges. The Il and Emuk Ranges are separated by the Gim Gorge (Pl. V., figs 1 and 3) through which the Fly River leaves the mountains to commence its 590 miles run to the sea. The Gorge is a narrow cleft less than 2,000 feet wide at the top and 1,500 feet deep, diminishing practically to river level down dip some 6½ miles downstream. A conspicuous though narrow air gap separates the Emuk from the Kaban Range. The three ranges present almost vertical cliffs, 1,500-2,000 feet high towards the north, but slope gently to the south. The highest point noted on the Il Range is about 4,400 feet, on the Emuk 5,700 feet, and on the Kaban Mt. Sari is about 7,000 feet.

The soft shales and sandstones immediately underlying the thick limestones have been much less resistant to erosion, and now constitute a wide stretch of low and subdued country at the base of the great limestone scarps, protected and modified by enormous talus slopes and residual blocks left by the receding scarps. The talus slopes and residual cover themselves have been modified by the tendency of the underlying shales to slump, the result being that they have assumed a low slope and possess a roughly mammilated surface at a distance from the scarps.

Below these soft strata the rocks are harder again, and becoming predominantly sandstones and conglomerates support high country in which has developed a series of conspicuous strike

ridges and dip slopes, the Melokin and Kuabgen being perhaps the most prominent (Pl. V., fig. 2). These constitute the southern limit of the Central Highlands proper. They are generally lowest where the Wok Feneng cuts through them in a gorge only a little less formidable than the Gim Gorge, and rise east and west outwards toward the divides with the Palmer and Alice Rivers respectively, where the relation of topography to geology becomes obscure. The Hindenburg Range comprising the core of the Central Highlands in this area is nowhere less than 8,500 feet high, some peaks reaching 10,500 feet. The Kuabgen Range rises to a height exceeding 4,400 feet, while the most prominent point on the Melokin Range is 4,700 feet. Further south, Observation Hill on a well developed strike ridge is 2,830 feet, and on its counterpart west of the Wok Feneng a peak 3,100 feet high was observed.

The Feneng is undoubtedly the main stream, but the Bol and the Wunik are only a little less important as water carriers. All the large streams are rapid and turbulent, have steep-walled valleys and are more or less choked with great boulders. Near the Feneng Base Camp the Feneng is relatively quiet for a distance of about 2 miles upstream, the width is 200-300 feet, and although shallow a canoe can be used with difficulty; but downstream the gradient to the mouth of the Gim Gorge averages over 90 feet per mile in a series of cascades, the width reducing to 150-200 feet. Between the junctions with the Wunik and the Bol the gradient increases from 60 to 110 feet per mile, width varying from 60 to 150 feet. Above Bol junction in the $2\frac{1}{2}$ miles traversed the river is a torrent falling at the rate of over 300 feet per mile and the stream is full of enormous boulders which almost bridge it in places.

A high terrace sloping downstream along the Feneng from just above Bol Junction where it is about 300 feet above present river level to near Base Camp where it falls to less than 50 feet indicates an earlier course of the stream. A series of soft horizontal thin bedded clays in the low country around the confluence of the Feneng and its tributaries Kup and Ing and south of Base Camp suggests the existence of quite a considerable lake in perhaps the not very distant past, formed probably through a great landslide damming the mouth of Gim Gorge.

Despite the precipitous and sometimes almost vertical slopes, the whole country is clothed in dense jungle with the exception only of the small and relatively few native gardens, and a scrubby but tough vegetation on the top of sandstone ridges. Numerous conspicuous bare rock scars on the cliffs of the limestone ranges indicate the prevalence of large rock falls. Somewhat less conspicuous but still numerous are similar scars on the cliffs of the sandstone ridges.

The rocks are usually well exposed in the streams, but these are not always completely accessible and much physical effort is required to climb in and out of gorges to study exposures.

The shale members have suffered considerable slumping so that these rocks are frequently obscured. Particularly is this the case with the thick Feing mudstones in the main Feneng. Smaller streams, tributaries of the Wunik, provided the best sections in these strata.

Stratigraphy.

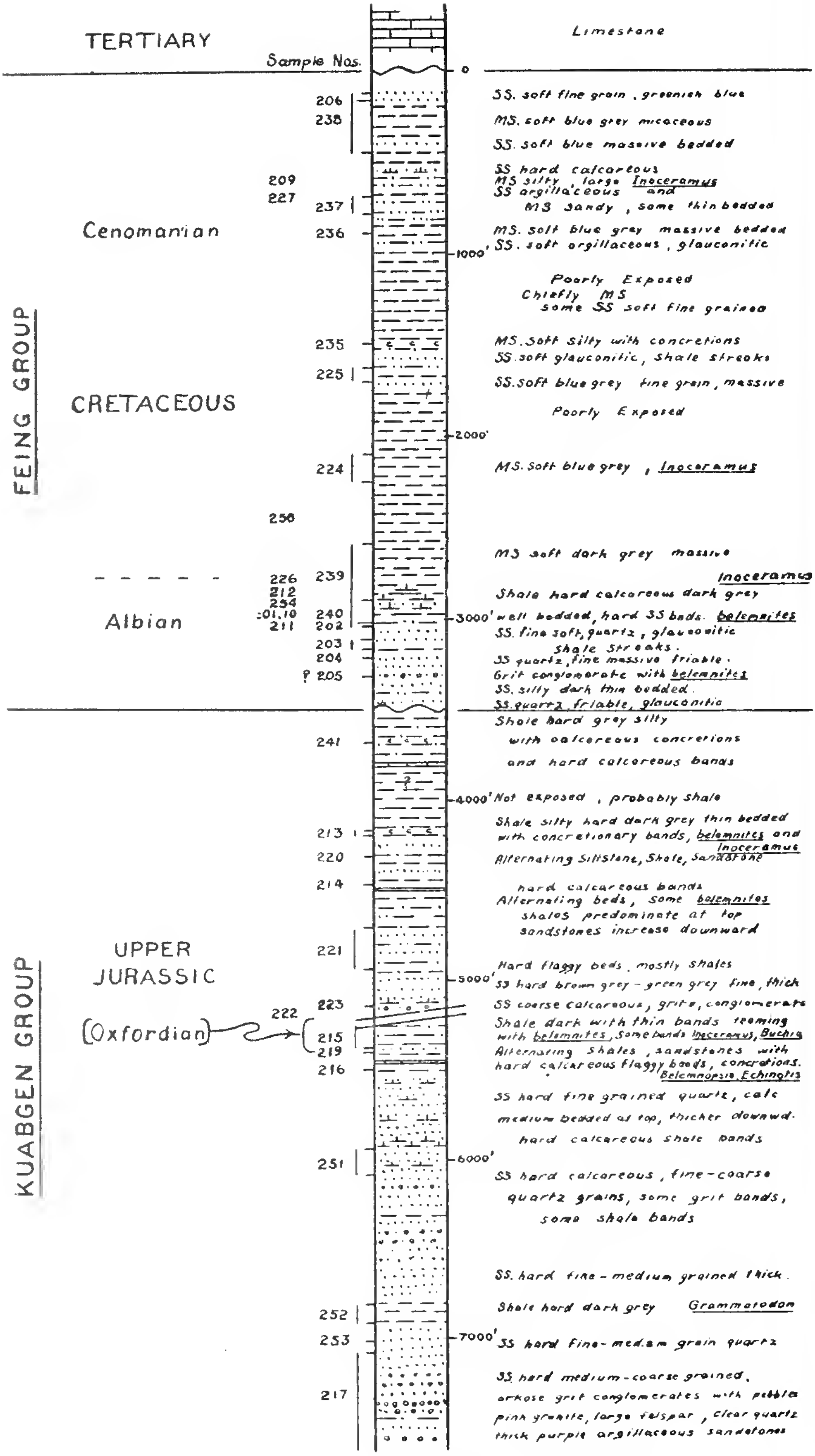
A thick section of marine sedimentary rocks totalling nearly 7,500 feet was found underlying the Tertiary limestones in the Feneng area. This section has been divided on lithological grounds into two distinct units of sedimentation named respectively Feing group and Kuabgen group. Both are dominantly argillaceous at the top and pass downwards into dominantly arenaceous strata, but the rocks of the lower Kuabgen group are slightly indurated and have a definitely older appearance.

Although the section is not very fossiliferous as a whole, *Inoceramus* and belemnites are fairly abundant in several widely scattered zones. Thus the age was recognized in the field as generally Mesozoic. Glaessner has examined the macro- and micro-fossils contained in the collected specimens and has assigned more specific age within the Cretaceous and Jurassic to the two lithological units. His determinations and conclusions are recorded in a paper entitled "Mesozoic Fossils from the Central Highlands of New Guinea," published simultaneously in these Proceedings.

The rock sample localities are shown on the accompanying geological map, and their position in the stratigraphic sequence on the columnar section for the Feneng area (fig. 1). This section illustrates the general character and thicknesses of the Cretaceous and Upper Jurassic sediments.

The contact between the Tertiary limestones and the Feing group has not been seen anywhere owing to the universal cover of talus at the foot of the great cliffs which mark the outcrop of these limestones everywhere in the Feneng area. However there is an abrupt and complete change in lithology and a big time break between them, the uppermost Cretaceous and the whole of the Eocene apparently being missing.

Chawner has reported the same situation in the Upper Palmer River some 20 miles east south-east, his Luap and Narin formations, sandstone and mudstone respectively, being almost identical in lithology, fauna and total thickness with the Feing group, while the Tertiary limestones from the two areas are also similar in character.



COLUMNAR SECTION for the FENENG AREA

FIG. 1.

However whereas Chawner postulates an angular unconformity between the Narin formation and the Kaban limestones, no evidence of an angular break was seen in the Feneng area. No actual contact was seen in the Palmer area either and the situation there was obscured also by faulting. In both areas the limestones appear to be underlain by the same Cretaceous formation, the close agreement in thickness and character between the Cretaceous sections exposed in the upper Palmer and the Feneng area suggesting that no persistent unconformity is present. Furthermore, wherever observed in the Feneng area the Feing mudstones appear to be dipping at about the same angle as the overlying limestones.

The evidence in the Feneng area suggests rather that the break between the Feing group and the Tertiary limestones represents chiefly a long period of non-deposition without appreciable folding or erosion.

Feing Group.

Extending from the foot of the great north-facing scarps of the Il, Emuk, and Kaban Ranges to the lower slopes of the Central Highlands is a wide valley-like area whose subdued topography is in marked contrast with the high and rugged character of the remainder of the Feneng area. A covering of limestone talus and residual blocks occupies most of the surface, but many of the deeper streams have cut through it to expose a thick section of sediments, chiefly mudstones, dipping relatively gently toward the south. This subdued terrain is terminated northward by a prominent though not especially high standstone ridge which dips south beneath the mudstones.

Examination has shown that the mudstones grade downwards into the sandstones, the whole forming a sedimentary unit to which the name Feing group has been given—the Wok Feing being the stream in which the best section of the upper part was observed.

The whole series was not seen in one continuous section, but different parts of it are well exposed in the Wok Feing, Bok, Feneng, Kup and Ing, also in Descent Creek. From these it has been possible to work up a composite section. The total thickness so measured amounts to 3,400 feet minimum, part of the 200-250 feet of beds obscured by talus at the foot of the limestone cliffs no doubt belonging in the Feing group. This thickness is only an approximation, for outcrops showing dip are rare in the upper part owing to the prevailing massive character of the rocks, while their tendency to slipping and slumping on a large scale make even the best observations of dips a little uncertain.

The upper 2,800 feet, well exposed in the Wok Feing and the Wok Bok, are predominantly argillaceous consisting mainly of soft massive grey to blue-grey mudstones and silty micaceous mudstones, but with some thick zones of soft greenish-blue fine-grained sandy mudstones and argillaceous sandstones especially near the top. The sandstones are sometimes thick-bedded, sometimes thin-bedded, and often contain glauconite. Cone-in-cone limestone also is found on several horizons.

Towards the bottom the mudstones become darker, harder and more silty to consist largely of hard dark-grey to black silty shales, generally micaceous and frequently pyritic, medium to massive bedded and exhibiting spheroidal weathering with a yellow-brown ferruginous incrustation and giving off a strong sulphurous odour. Some of the beds are very calcareous, extremely hard and brittle.

Thin sandstone bands appear in these hard shales, becoming more important downward, and the section grades into argillaceous sandstones through a transition zone perhaps 100 feet thick.

The basal, dominantly sandstone, part of the group measures some 500 feet in the Wok Kup. No direct measurement was made in the Wok Bok because that stream plunges over a high waterfall in these rocks and is inaccessible, but from the elevation and dip the thickness would appear to be of the same order.

The sandstones are argillaceous at the top but less so downwards. The sand grains consist almost entirely of sub-angular to slightly rounded clear quartz, generally of fairly uniform size in individual beds. Glauconite is a common constituent throughout, distribution varying from even dispersion to scattered aggregation in pockets: occasionally it is so abundant as to give the rock a dark-green colour, often it is entirely absent. Thin beds of grey silty shale occur, particularly in the upper half of the sandstones. At some horizons thin grey shale streaks are conspicuous.

Bedding is generally medium to thick and mostly well defined. The strata are often fairly hard, especially at the top, with some very hard siliceous bands, but many of them are quite uncemented although tightly compacted and fall to pieces on being struck. There are also important zones of soft friable white sandstone consisting almost entirely of pure clear quartz especially towards the bottom.

Grain size is chiefly fine to medium becoming generally coarser downwards where there are some grits. Slightly waterworn pebbles of hard calcareous gritty conglomerate found in the Wok Kup downstream from the outcropping sandstones contain, in addition to abundant quartz and numerous belemnites, rounded

pebbles of hard calcareous shale and dark siliceous rock undoubtedly derived from the underlying Kuabgen group. These were not seen in place anywhere but it is believed they almost certainly come from somewhere in the basal Feing sandstones. A hard waterworn concretionary pebble containing canaliculate belemnites found among the stream pebbles at the same place is thought also to have been derived from the Kuabgen group by way of these conglomerates.

The Feing group generally is not visibly very fossiliferous. In the upper argillaceous part thin bands rich in large *Inoceramus* sp. were found in Descent Creek from a position high in the section, in the Wok Feing low in the section, and in the Woks Kup and Ing about the bottom. The mudstones contain also a fairly rich assemblage of foraminifera, which Glaessner (see p. 165) regards as establishing a Cenomanian age for the upper part of the Feing group.

In the Wok Feneng just above its junction with the Wok Wunik the belemnite *Parahibolites blanfordi* occurs fairly commonly in hard dark shales of the transition zone. Similar belemnites also were seen on about the same horizon in the Wok Ing. Foraminifera from this zone are regarded by Glaessner as indicating an Albian age.

No recognizable fossils at all were recovered from the basal sandstone formation, *in situ*, but weathered fragments of belemnites up to nearly an inch in diameter were found in the Wok Kup downstream from the outcropping sandstones. They occur among stream pebbles which included the belemnite bearing conglomerate mentioned above, some of the included belemnites being apparently the same as those found loose. Sandstone boulders with similar belemnites were observed in the Wok Ing adjacent to outcrops of lithologically similar rocks underlying the transition zone, but here again the fossiliferous deposits were not seen in place. Cylindrical holes resembling in shape and size the belemnites occurring loose in the Wok Kup, sometimes empty sometimes filled with hard clay, were observed in thin bands in the sandstones exposed in the Wok Kup fairly low in the section, and in the Woks Bok and Ing near the top. Possibly these cavities once contained belemnites, although these fossils generally seem to be more resistant than the containing strata.

In any case, as indicated previously, the belemnite bearing conglomerate is considered to have come from the basal sandstones of the Feing group. Unfortunately, while the belemnites in the conglomerates are well preserved, it has been impossible to extract them from the rock so that their features can be examined. For this reason Glaessner is unable to determine them, although he states that they have a Cretaceous rather than Jurassic aspect. Since the basal sandstones form a continuous series of strata with the transition zone which has been established as Albian, it is probable that they, too, are of that age, or very little older.

Thus the Feing group is referred to the middle Cretaceous, Cenomanian-Albian. The palaeontological sub-division of this group into Cenomanian and Albian agrees very closely with the lithological sub-division into an upper, dominantly mudstone, and a lower, dominantly sandstone, formation, except that the lithological basis would include in the upper part the hard dark shales at the top of the transition zone which however contain Albian fossils.

In thickness, fossils and general character, the Feing group is almost identical with the combined Narin and Luap formations described by Chawner from the upper Palmer River, the only difference being that the basal sandstones in the Palmer appear to be thicker though the bottom of the section was not reached, and that the transition zone appears to be thicker too, thus:—

Feneng Area.	Feet.	Upper Palmer.	Feet.
Feing group:		*Narin formation:*	
Upper, chiefly mudstone ..	2,800	Chiefly mudstone ..	2,125
Transition zone	100	*Luap formation:*	
Lower, chiefly sandstone ..	500	Transition zone ..	500
		Sandstone	825
	3,400		3,450

No contact between the Feing group and the underlying Kuabgen group was seen. However the Kuabgen group generally looks distinctly more indurated than the Feing, while the palaeontological evidence shows that there is a considerable time interval between the two groups, the uppermost Jurassic and much of the lower Cretaceous being absent. These points, together with the sharp lithological change from shales at the top of the Kuabgen to sandstones at the base of the Feing, with glauconite and gritty conglomerates containing weathered pebbles of the underlying Kuabgen group, suggest an erosional unconformity of some dimensions. In the Wok Wunik the Kuabgen shales are dipping at a higher angle than the overlying Feing beds where dips could be read; but as there is a gap of about 1,000 feet in which there are no outcrops and a still greater interval between exposures on which dips can be measured, while there is evidence in both units of increase in dip towards a maximum in the vicinity of the group boundary, this cannot be regarded as demonstrating an angular discordance. The general monoclinal conditions observed in the Feneng area give the impression that an angular divergence of no more than a few degrees at most can be expected.

Kuabgen Group.

The strata belonging to this group occupy the increasingly higher and more rugged country on the south flank of the Central Highlands. They support a number of high strike ridges, prominent among which are the Melokin and Kuabgen Ranges, the latter giving the group its name.

The upper part of the group is rather poorly exposed in the area visited and the section has been made up as a composite from outcrops inspected in the Woks Feneng and Wunik. The lower and greater part of the group however is exposed practically as one continuous outcrop in the Wok Feneng and the Bol River, which here flow through gorges not uniformly so high but almost as difficult of access as the Gim Gorge.

The highest beds seen lie about 100 feet below the top of the group and consist of hard grey silty micaceous shales with calcareous concretions, massive bedded at the top but becoming thinner bedded downwards with some very hard calcareous bands intercalated. These total about 250 feet in thickness and are followed by a gap of similar dimensions in which no outcrops were seen. Judging by the topography it is believed that this gap and also that at the top represent mainly argillaceous sediments. The next outcrops seen were hard dark-grey thin-bedded indurated-looking silty micaceous shales with hard concretionary bands and containing belemnites and *Inoceramus*. Below these are about 600-800 feet of beds, sometimes dominantly sandy, sometimes dominantly shaly, grey to greenish-brown in colour, thin to thick bedded, generally hard and often flaggy with frequent harder very calcareous bands; sometimes alternating hard sandstones, argillaceous sandstones and silty shales with some pyrite nodules. The shales often look indurated but the sandstones, though usually very hard, show no sign of alteration.

The sandstones increase in importance as the section is descended, becoming thicker and more numerous until there are some 250 feet consisting almost entirely of hard brownish-grey to greenish-brown fine grained sandstone, medium to thick bedded, with a thick hard calcareous coarse clear quartz sandstone including gritty bands containing some thick-shelled pelecypods, near the bottom.

At this stage the sequence is interrupted by structural complications in both the Wok Feneng and Wok Wunik, possibly 100-200 feet higher in the Feneng than the Wunik. In the Wok Feneng the monoclinal conditions are disturbed by two small anticlinal folds with associated faulting indicated by irregular dips and strikes, slickensides, breccias, calcite veins, and visible small faults. Similar manifestations of faulting are evident also in the Wok Wunik where, however, the traverse was not continued far enough to detect whether it is connected with folding.

No direct evidence was found to show the magnitude and nature of the faulting, but there is reason to believe that section is cut out rather than repeated, because a highly fossiliferous shale of peculiar appearance which occurs on the north side of the fault was not seen anywhere on the south side. Thus it is concluded, not very surely, that downthrow is to the south. However, the fossiliferous shale on the upthrow side is underlain by alternating

beds rather similar to those already described, suggesting that the same unstable conditions existed throughout the deposition of the strata now found on both sides of the fault, and therefore that the fault may be of relatively small dimensions.

The total thickness estimated for the upper part of the Kuabgen group is 1,710 feet with a thick coarse sandstone containing grit bands near the bottom. A conglomerate consisting of hard grey shale and sandstone pebbles in a fine sandy matrix observed in the fault zone in the Wok Wunik probably belongs here. Pebbles in this conglomerate resemble some of the hard calcareous shales and sandstones underlying the peculiar fossiliferous shales just mentioned, suggesting at least an interformational erosion interval. This, apart from the faulting, provides a convenient horizon for tentatively dividing the Kuabgen group into an upper and a lower part, the former being that already described.

The highest known member of the lower part is the above mentioned very fossiliferous shale adjacent to the fault in the Wok Feneng. A thickness of about 120 feet is exposed, with the top missing, consisting of relatively soft dark-grey shales, medium to thick bedded, silty and slightly micaceous at the top A zone perhaps 20 feet thick near the bottom contains several thin bands teeming with fossils, some with belemnites, others with large *Inoceramus* and *Buchia malayomaorica*. (Sample 215.)

Below this are about 20 feet of greensands interbedded with grey to purple-grey shales containing pyrite, belemnites, ammonites, and pelecypods (sample 219); then about 100 feet of hard thin-medium bedded flaggy silty shales and fine grained sandstones, sometimes alternating; finally grading down into a thick sandstone formation, mostly fine grained at the top and becoming coarser downwards to finish as dominantly gritty arkose conglomerates some 900 feet thick, the lowest beds seen. There are several grit beds and shale bands interspersed through the sandstones, one important dark-grey shale member near the bottom being 110 feet thick and containing *Inoceramus*.

The conglomerates are hard, cemented, well consolidated, and generally massive bedded, consisting principally of angular to sub-angular clear quartz fragments with sub-angular pebbles up to 8 inches through of coarse pink granite with clear quartz and large pink felspars, some pink felspar and rare small well rounded pebbles of grey quartzite and hard grey sandstone. There are many thick beds of grey argillaceous sandstone which weather purplish and constitute the vehicle for numerous immense landslides, especially along the Bol River the north bank of which is really a great dip-slope whose foundations are being eroded away continuously by the swift waters of the Bol.

The total thickness of the lower Kuabgen is 2,330 feet minimum, making a total for the group of 4,040 feet observed, with an unknown amount of section missing through faulting and the

base not having been reached. The Wok Feneng was traversed with greater and greater difficulty upstream until what seemed like a definite reversal in dip was encountered. Subsequent observations from Kuabgen Range indicated that this was not the case and that no more than a small local fold occurs there. However, at the point reached the gradient of the stream exceeds 300 feet per mile and no pebbles were found other than the sandstones and conglomerates already known. Consequently it is considered that very little if any more section is exposed in the Feneng, and at any rate nothing below the conglomerate outcrops there.

The Kuabgen group is even less fossiliferous generally than the Feing group, but macro-fossils are visible on several horizons. Belemnites were seen in two zones in the upper part, both in the Wok Feneng; one from dark-grey flaggy argillaceous siltstone or fine sandstone about 1,000 feet down in the section, the other from hard dark thin bedded shale containing concretions, about 400 feet higher, where they are associated with *Inoceramus*. Glaessner has determined the belemnite from the latter outcrop to be *Belemnopsis gerardi*.

As mentioned previously a shale band about 20 feet thick in the upper part of the lower Kuabgen group contains thin very richly fossiliferous layers. One of these is teeming with belemnites recognized by Glaessner as *Belemnopsis gerardi*, another is practically built up of pelecypods which he considers are *Buchia malayomaorica* with some large *Inoceramus* sp. Immediately underlying are alternating beds one of which, a pyritic concretionary greensand, contains *Belemnopsis* cf. *indica*, *Meleagrinella braamburiensis* and a few indeterminate ammonites.

The thick shales towards the bottom of the exposed section contain *Grammatodon* (*Indogrammatodon*) *virgatus* and a few *Inoceramus* sp.

Glaessner considers that the palaeontological evidence demonstrates an Oxfordian age for the *Buchia-Belemnopsis* beds and a possibly Callovian age for the underlying *Echinotis* and *Grammatodon* beds, making the Kuabgen group generally Upper Jurassic.

Since the base of the Kuabgen group has not been reached anywhere in this part of New Guinea, there is no direct evidence of the character of the immediately underlying rocks. However, since the lowest strata seen consist almost entirely of a considerable thickness of fresh looking and only slightly rounded granite derivatives which become coarser grained as the section is descended, it is believed that the granite surface which furnished these sediments was situated near-by and that in all probability granite basement underlies the Kuabgen conglomerates at no great depth.

This situation occurs in the Chimbu area, some 250 miles to the east, where Noakes (1939) reports that a very thick section of Mesozoic rocks rests directly on granite, palaeontological examination setting the age of the basal sediments at Upper Jurassic.

IGNEOUS BOULDERS.

Numerous well rounded pebbles and boulders of a dense igneous rock with large augite or hornblende crystals in a light-grey ground mass, possibly andesitic, occur in the Bol River and further down in the Wok Feneng. The source of the boulders was not found but as they do not occur as components of any of the sedimentary rocks in the area, it is inferred that they come from dykes in the upper Bol valley.

Notes on Mesozoic Geological History.

Mesozoic rocks are known from a number of widely scattered points in New Guinea, principally along the Central Highlands. These occurrences have been listed by Glaessner (1943) who has discussed their correlation. He suggests that in Jurassic times, part of western and central New Guinea was a geosynclinal area which extended possibly into eastern New Guinea.

The information generally is very scanty, a big proportion of the occurrences being known only from stream pebbles and very few good sections having been inspected. Most of the information so far obtained is barely sufficient to give an idea of distribution, and provides little basis for deductions concerning geological history.

Although still meagre, more is known perhaps of that part of the Central Highlands which includes the Feneng area than of any other region in New Guinea.

Data presented in this paper indicate that the oldest Mesozoic sediments seen in the Feneng area, arkose conglomerates grits and sandstones of the lower Kuabgen group, Callovian in age, in all probability lie very close to granite basement. In the Feneng region generally, Callovian fossils have been reported from the Strickland River about 50 miles south-east of the Wok Feneng, from the Sepik River about 50 miles north, and from the Digoel River 70 miles north-west. Pre-Callovian also has been reported from the Strickland.

The character of the lower Kuabgen group suggests that the immediately adjacent land surface had been eroded down to granite basement prior to the beginning of Kuabgen deposition. Hence it seems likely that the Feneng area itself was dry land during most of lower Mesozoic times at least. The distribution of Upper Jurassic rocks in the region suggests that a Mesozoic geosyncline was developed mainly north of the Feneng area and

that the granite land mass which provided the lower Kuabgen sediments lay to the south and south-west, possibly connected with the Australian shield.

The subsidence which initiated the Upper Jurassic marine transgression in the Feneng area did not continue uniformly, fluctuations in rate of subsidence being denoted by irregular alternations in lithology, especially of the middle to upper Kuabgen deposits. The conglomerates at the base of the upper Kuabgen group are evidence of at least one important oscillation which raised the lower Kuabgen sufficiently to undergo erosion.

There is a big gap in the Feneng record between Oxfordian and Albian, the lowermost Cretaceous and possibly the uppermost Jurassic being absent. Representatives of some of the missing stages have been reported from the Sepik River, the Om and the Strickland. Possibly uplift of the southern marginal area of the geosyncline during the early Cretaceous at least, favoured denudation of whatever post-Oxfordian strata may have been deposited, before renewed submergence in Albian time started deposition of the Feing group.

Waterworn pebbles of Kuabgen type occurring in the basal Feing sandstones indicate some erosion of the Jurassic strata, while the general quartz sandstone nature of these basal beds, with frequent subangularity of grains, indicates that once again a granite land area was the principal source of the sediments. This idea is supported also by the abundant glauconite in the Feing group.

Subsidence seems to have been more uniform and widespread in the upper Feing, resulting in the basal sandstones grading into mudstones which persisted, with relatively minor intercalations of sandstone, through a considerable thickness of strata and occupying at least a large part of Cenomanian time.

Another big time gap occurs between the Cenomanian and Tertiary. Here there is some slight evidence of a long period mainly of non-deposition. Possibly during this period major regional subsidence resulted in this area being covered by deep water far removed from land and in which conditions were not favourable to abundant marine life.

A striking feature of the whole Mesozoic section in the Feneng area is the universal prevalence in the sandstones and grits of clear quartz grains, most frequently only partially rounded. There seems to be little doubt that the Feing and Kuabgen groups were derived almost entirely from a granitic source, with relatively minor amounts of material eroded from already deposited Mesozoic sediments.

As indicated above, the Feneng area appears to have been located about the southern margin of an Upper Mesozoic geosyncline with a granite land surface extending to the south and south-west. The absence of any appreciable angular discordance

between the lithological units where big time breaks are shown by palaeontological studies, proves that this area was only slightly affected by the intense orogenic movements experienced in other parts of the south-west Pacific at the end of the Jurassic and Cretaceous Periods.

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Explanation of Plate.

PLATE V.

FIG. 1. Looking south from Observation Hill, showing the Gim Gorge of the Fly River between the Emuk and II Ranges. Precipitous scarps 1,500-2,000 feet high held up by Tertiary limestones. Lower, more subdued topography typical of Feing mudstones (Cretaceous).

FIG. 2. Topography developed in Kuabgen group. Long dip slopes and strike ridges. Melokin Range in middle distance, towering scarp of Kaban Range. Tertiary limestone in background. View from Kuabgen Range looking east-south-east across Feneng and Bol Valleys.

FIG. 3. Looking north through the mouth of the Gim Gorge into the Feneng area, showing the almost vertical limestone walls, 1,500 feet high, and the boulder-strewn channel of the Fly River at the base.


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Art. X.—*Mesozoic Fossils from the Central Highlands of New Guinea.*

By M. F. GLAESSNER, Ph.D.

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Abstract.

Upper Jurassic and middle Cretaceous mollusca from Central New Guinea are described, including genera and species known from the Upper Jurassic of north-western India and of the East Indies (*Buchia-Belemnopsis* fauna), from the Upper Albian and Cenomanian of southern India and from the Aptian-Albian of Australia. Lists of foraminifera are given and the stratigraphic position of fossiliferous Mesozoic sediments of Papua and New Guinea is discussed.

Introduction.

The samples of fossiliferous rocks and fossils described in the following communication were collected in 1938-1940 by geological field parties engaged in reconnaissance surveys on behalf of Island Exploration Company and Australasian Petroleum Company. These parties were led by Dr. W. D. Chawner, Mr. N. Osborne, and Dr. S. W. Carey. A small number of fossils collected in 1939 by Mr. L. C. Noakes, then Assistant Government Geologist of the Territory of New Guinea, have also been studied.

For detailed accounts of field observations in the Mesozoic sediments of Papua, including localities at which rock samples and fossils were collected, reference should be made to publications by N. Osborne (1944), and S. W. Carey (1944). The author has discussed recently general questions of stratigraphic correlation in a wider area (Glaessner, 1943).

The fossils described in the following account were taken from the Kuabgen group (Upper Jurassic) and the Feing group (Albian-Cenomanian) which form a sequence of strata 7,500 feet thick in the Fly River headwaters in Western Papua, from the two lower divisions of the "Wahgi Series" (Jurassic, Aptian-Albian) of the Chimbu-Mt. Hagen area, Territory of New Guinea, and from the Lower Cretaceous Purari formation on the Middle Purari River, Papua (see map). Type specimens have been deposited in the collection of the Geology Department of Melbourne University, and representative fossils and rock samples will be forwarded to the Commonwealth Geological Collection, Canberra.

The writer wishes to express his gratitude to Mr. N. Osborne and Dr. S. W. Carey for valuable material and useful information placed at his disposal, to Dr. F. W. Whitehouse for the generic determination of one of the fossils, to Dr. N. H. Fisher, former Government Geologist, Territory of New Guinea, for permission to quote from an unpublished report by L. C. Noakes, and to the Directors of the Island Exploration Company and Australasian Petroleum Company for permission to publish this contribution.

Jurassic Fossils.

FORAMINIFERA.

A small number of foraminiferal tests representing the genera "*Cristellaria*", *Nodosaria*, *Dentalina* and *Epistomina* occurs in the dark shales of the Kuabgen group of the Upper Fly River (samples 215, 213). These are generally the most common genera of foraminifera occurring in Upper Jurassic clays and shales.

MOLLUSCA.

1. **Grammatodon (Indogrammatodon) virgatus** (J. de C. Sowerby).

(Pl. VI., figs. 1*a-b*.)

Cucullaea virgata J. de C. Sowerby, 1840. Trans. Geol. Soc. (2), vol. 5, pl. 22, figs. 1-2.

Grammatodon (Indogrammatodon) virgatus, L. R. Cox, 1937. Proc. Malacol. Soc. London, vol. 22, p. 195, pl. 15, figs 8, 9.

Grammatodon (Indogrammatodon) virgatus, L. R. Cox, 1940. Pal. Indica., ser. 9, vol. 3, pt. 3, p. 74, pl 2, figs. 22-30.

Material.—A single specimen, almost complete, both valves preserved but distorted by dorso-ventral compression.

Occurrence.—Black shale, lower part of Kuabgen group, about 3,300 feet below the top (sample 252).

Description.—The characters of this specimen agree with *G. virgatus* as redescribed by Cox. The main distinguishing features of the subgenus *Indogrammatodon*, the inequilateral shape and the difference in ornamentation of the two valves are clearly visible. The radial ribs in the left valve are stronger and more widely spaced. The umbones are placed at about the anterior two-fifths of the length. About 18-20 ribs are visible in the left valve anterior to the rounded carina, and about 16 are distinguishable on the anterior half of the right valve, with a few finer riblets intercalated between the 8th to 12th ribs. About 12 less distinct postero-ventral ribs are also recognizable. The posterior area of the right valve bears two or three radial threads.

The large number of radial ribs, their shape and distribution and other well preserved characters of ornamentation agree with *G. (I.) virgatus*, rather than with the similar *G. (I.) egertonianus* (Stoliczka). As far as distortion does not interfere with measurements, they are in agreement with *virgatus*, particularly the position of the umbones. *G. (I.) egertonianus* is more inequilateral.

Measurements.—Length of hinge margin 33 mm., umbo about 13-14 mm. from the anterior end of the hinge margin; height uncertain, probably more than 15 and less than 20 mm.

Age.—According to L. R. Cox, *G. (I.) virgatus* ranges from the *macrocephalus*-beds of the Lower Chari of Kachh, north-western India (Upper Bathonian or Lower Callovian) through the Middle Chari (Callovian) and the *athleta*-beds to the lower Dhosa Oolite of Lower Oxfordian (Upper Divesian) age.

2. **Meleagrinella braamburiensis** (Phillips).

(Pl. VI., figs. 2-4.)

Avicula braamburiensis nom. nud., J. de C. Sowerby, 1829, in: Murchison. Trans. Geol. Soc., (2), vol. 2, p. 323.

Avicula braamburiensis, Phillips, 1829. Ill. Geol. Yorkshire. p. 140.

Pseudomonotis braamburiensis, Douglas and Arkell, 1932. Quart. Journ. Geol. Soc., vol. 88, p. 163, pl. 12, figs. 5, 6.

?*Aucella* sp., Wandel, 1936, N. Jahrb. f. Min., Beil.-Bd. 71, (B), p. 461, fig. 1a-c.

Material.—Numerous closely-packed small single valves, about 24 examined.

Occurrence.—Black sandy shale, with *Belemnopsis* cf. *indica*, lower part of Kuabgen group (sample 219). About 40 feet below the *Buchia*-bed.

Description.—" Left valve moderately flattened, much less inflated than in *Pseudomonotis echinata* (Sow.), ornamented with some 25-30 fine thread-like ribs, which are faintly knotted at long intervals where crossed by some of the more prominent of the indistinct growth lines. The ribs are separated by wide, flat sulci, at least three to four times as wide as the ribs, and between every pair is a still finer secondary rib. The ornament is essentially radial, very little concentric element entering into it. Umbo small, much less tumid than in *P. echinata*, salient about 1½ mm. dorsal to the hinge-line.

Right valve nearly flat, but with surface rising slightly towards the umbo, which is not salient dorsal to the hinge line. Ornament as in the left valve, but more reticulate, owing to the concentric growth lines being more visible Auricles small, the ribs covering them in both valves." (Douglas and Arkell).

Measurements.—Height about 16-17 mm., length about 9-14 mm. (left valves).

The available material from the Jurassic of Central New Guinea agrees well with *M. braamburiensis* rather than with the typical wide-ranging *M. echinata*, mainly in the characters of the left valve which is less inflated, with "essentially radial" ornamentation. The right vales are smooth or show only faint traces of radial threads and weak concentric growth lines. The new specimens also resemble a form considered by Wandel as an "*Aucella*" belonging to the group of *A. malayomaorica* Krumbeck. The strongly-developed angular posterior auricle, the straight hinge margin and the deep, narrow byssal notch agree with *Echinotis* and distinguish these shells from *Buchia*. The concentric ornament is much reduced, as in *M. braamburiensis.*

Measurements.—Height about 16-17 mm., length about 9-14 mm. (left valves).

Age.—*M. braamburiensis* was described from the Lower Oxfordian of England. Wandel's "*Aucella*" comes from the middle and upper part of the Lower Oxfordian of Misol (Demú limestone and Lilintá marly limestone). L. R. Cox (1940) found the majority of his specimens of *M. echinata* from the Bathonian of Kachh closely resembling *M. braamburiensis.* He states that the stratigraphic difference which exists in England between the typical *M. echinata* (Bathonian) and *M. braamburiensis* was not observed in the Indian material.

3. **Buchia malayomaorica** (Krumbeck).

(Pl. VI., figs. 5, 6, 7*a-b*.)

Aucella plicata (non Zittel), G. Boehm, 1911, N. Jahrb. f. Min. (i), p. 13, pl. 2, figs. 1-4.

Aucella malayomaorica Krumbeck, 1923, Pal. v. Timor, Lfg. 12, Abh. 20, p. 65, pl. 2, figs. 2-12, 17; pl. 6, fig. 13.

Aucella plicata (non Zittel), Trechman, 1923. Quart. Journ. Geol. Soc., vol. 79, p. 266, pl. 17, figs. 4-8.

Pseudomonotis sp., Broili, 1924. Wet. Mededeel., vol. 1, p. 10, figs. 10, 11.

Aucella boehmi Marwick, 1926. Trans. N.Z. Inst., vol. 56, p. 305, pl. 71, figs. 10-13.

Aucella plicata (non Zittel), Kruizinga, 1926. Jaarb. Mijnw., vol. 54, Verh., pt. 1, p. 17.

Buchia boehmi, Marwick, 1934. Proc. Fifth Pacif. Sci. Congr., p. 949.

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Aucella malayomaorica, Wandel, 1936. N. Jahrb. f. Min., Beil.-Bd. 75, (B), p. 456, pl. 15, figs. 5, 6; pl. 17, figs. 1-11.

Buchia malayomaorica, Teichert, 1940. Journ. Roy. Soc. W. Austr., vol. 26, p. 109.

Buchia malayomaorica. Glaessner, 1943. Proc. Roy. Soc. Vict., vol. 55, pt. 1, p. 45.

Material.—Numerous right and left valves, about 24 specimens examined.

Occurrence.—Black shale with *Inoceramus* and *Belemnopsis gerardi,* top of lower division of Kuabgen group (sample 215), locally forming a shell breccia. Also in dark-red to chocolate-coloured shale, about 2,700 feet above base of Chimbu-Wahgi section (Lower Wahgi valley, Noakes coll., sample 57) and in similar stratigraphic position in green calcareous shale 18 miles east of Mt. Hagen aerodrome (Noakes coll., sample 78). *Buchia malayomaorica* has been described from Timor, Rotti, Jamdena, Ceram, Boeroe, the Soela Islands, Misol, Boeton, East Celebes, Western New Guinea (Itebere R., Kamoendan River headwaters, Amberbaken district) and New Zealand (Locality 1193, West of Waikiekie Stream, Kawhia Harbour).

Description.—This species was fully described by Krumbeck (1923), Marwick (1926), and Wandel (1936). The new specimens agree with these descriptions. The outline of the shell shows little variation. The anterior and posterior margins of the valves are nearly parallel ("forma typica"). The approximately rectangular outline in this species differs markedly from the oblique shape of typical representatives of the genus. The surface ornamentation is variable. Krumbeck observed this variability and stated that almost all right valves showed radial as well as concentric ornamentation while only rare left valves had distinct radial ribs. In the present material variability of the radial ribs affects both valves about equally.

Measurements.—Adult valves are about 30 mm. high and about 20 mm. long, but the ratio is variable.

Age.—Upper part of Lower Oxfordian or lower part of Upper Oxfordian. (Approximately zone of *Cardioceras cordatum* ?).

4. **Inoceramus** sp.

Inoceramus occurs in at least two horizons in the Kuabgen group (samples 215, 213) but the available material is not sufficiently well preserved to permit specific identification. Fragments of large shells resemble *I. haasti* Hochstetter as well as *I. subhaasti* Wandel and *I. galoi* G. Boehm. Fragments of *Inoceramus* occur with *Buchia malayomaorica* in the Chimbu-Wahgi section (Noakes' sample 57).

5. **Belemnopsis gerardi** (Oppel).

(Pl. VI., figs. 8, *9a-b*.)

Belemnites gerardi, Oppel, 1865. Pal. Mitt. a.d. Mus. d. Bayer. Staates, pl. 88, fig. 1.

Belemnites gerardi, Uhlig, 1910. Pal. Indica, ser. 15, vol. 4, p. 386, pl. 93.

Belemnopsis gerardi, Kruizinga, 1921. Jaarb. v. h. Mijnw., vol. 49, Verh. pt. 2, p. 163, pl. 1, fig. 1, 3.

Belemnites gerardi, Broili, 1924. Wet. Mededeel, vol. 1, p. 8, pl. 2, fig. 9.

Belemnopsis gerardi, Stolley, 1929. Pal. v. Timor, Lfg. 16, Abh. 29, p. 151, pl. 248, figs. 16-32, pl. 249, figs. 1-3.

Belemnopsis gerardi, Spath, 1933. Pal. Indica, n.s., vol. 9, Mem. 2, pt. vi., p. 660ff.

Belemnopsis gerardi, Spath, 1939. Pal. Indica, n.s., vol. 25, Mem. 1, pt. iii., p. 135.

Material.—Four well-preserved specimens and about 20 fragments.

Occurrence.—Abundant in black shale with *Buchia malayomaorica* and *Inoceramus*, top of lower division of Kuabgen group (sample 215), also in upper division, about 1,100 feet higher (sample 213).

Remarks.—This is a controversial species. Without detailed examination of large numbers of well-preserved specimens and comparison with the holotypes of several similar named species which are evidently variable and overlap morphologically, nothing useful can be added to the controversy about the synonymy of this group. The new specimens agree with some of those figured by Uhlig from the Spiti shales (l.c. pl. 93, figs. 7, 9), by Kruizinga from Taliaboe and Mangoeli, Soela Islands, and by Stolley from Timor. Broili figured a specimen from Western New Guinea (Kamoendan River headwaters) as *B. gerardi*. While resembling the present material in its general character it differs in shape, having its greatest width below the middle of the length of the guard, as in *B. taliabutica* (G. Boehm). *B. alfurica* G. Boehm and a similar form described by Teichert from Broome, Western Australia, as *B. cf. alfurica* have a deeper ventral groove, a more circular transverse section, slender shape and narrower alveolar part.

Age.—Notwithstanding the controversy about the synonymy of *B. gerardi* and the age of its holotype, this fossil is a valuable stratigraphic marker for the Oxfordian in the eastern part of the Sunda archipelago. Abundant occurrence like that observed in the *Buchia-Belemnopsis* bed of the Kuabgen group is recorded from the Wai Galo beds of the Soela Islands. This important fossiliferous horizon is assigned by Spath to the *cordatum*-zone of the Oxfordian and its stratigraphic position is close to that of the Belemnite beds at the base of the Spiti shales in the Himalaya. In his recent discussion of *B. gerardi*, Spath came to the conclusion that its range is Upper Jurassic (and possible Lower Neocomian).

6. **Belemnopsis** cf. **indica** Kruizinga.

cf. *Belemnopsis indica*, Kruizinga, 1921. Jaarb. Mijnw., vol. 49, Verh. pt. 2, p. 171, pl. 3, fig. 1-3.

cf. *Belemnopsis indica*, Stolley, 1929. Pal. v. Timor, Lfg. 16, Abh. 29, p. 165, pl. 250, figs. 7-10.

cf. *Belemnopsis indica*, Kruizinga, 1931. Leidsche Geol. Mededeel., vol. 5, p. 369, 377.

cf. *Belemnopsis indica*, Stolley, 1935. N. Jahrb. f. Min., Beil.-Bd. 73, Abt. B. p. 50.

Material.—Two fragmentary rostra, apical portion not preserved.

Occurrence.—Sandy shale, with *Meleagrinella braamburiensis*, lower part of Kuabgen group (sample 219). About 40 feet below the bed with *Buchia* and *Belemnopsis gerardi*.

Remarks.—This species is characterized, according to Kruizinga, by the shape of its rostrum. The greatest width is in the middle, and the dorso-ventral diameter is 20 per cent. shorter than the transverse diameter. These features are clearly recognizable in the two available fragments which are quite unlike any of the numerous fragments of B. gerardi from a slightly higher horizon. They resemble however *B. calloviensis* (Oppel) as figured by Spath (1927, p. 6, pl. 1, fig. 7).

Age.—*B. indica* is known from the Oxfordian of Taliaboe and Rotti and the "Lower Oxfordian" of Boeroe, Mangoli and Misol.

Cretaceous Fossils.

FORAMINIFERA.

Feing group.—A rich and varied foraminiferal fauna occurs in the argillaceous rocks of the Feing group. Only preliminary determinations are at present available. They indicate clearly late Lower Cretaceous to early Upper Cretaceous age.

The lowest fossiliferous sample (210) contains the following fauna:—

Trochamminoides sp.
"*Cristellaria*" sp.
Marginulina spp.
Nodosaria sp.
Lagena sp.
Pleurostomella sp.
Gyroidina nitida Reuss.
Anomalina sp.
Globigerina infracretacea Glaessner.

The occurrence of *Pleurostomella* is important as this genus is not known in earlier than late Albian beds. The assemblage does not contain any distinctive Upper Cretaceous elements.

It is followed by a rich fauna occurring in numerous samples from the higher part of the Feing group. This fauna includes:—

Rhizammina sp.
Ammodiscus sp.
Haplophragmoides sp.
Trochamminoides sp.
Ammobaculites sp.
Textularia washitensis Carsey.
Textularia rioensis Carsey.
Dorothia filiformis (Berthelin).
Dentalina communis d'Orbigny.
Nodosaria affinis Reuss.
Nodosaria obscura Reuss.
Nodosaria soluta Reuss.
Tristix excavata (Reuss).
Lenticulina sp.
Marginulina sp.
Saracenaria sp.
Globulina lacrima Reuss.
Buliminella sp.
Bulimina reussi Morrow.
Pleurostomella subnodosa Reuss.
Gyroidina nitida Reuss.
Anomalina spp.
Globigerina infracretacea Glaessner.
Globigerina spp.
Globotruncana aff. *appenninica* O. Renz.

The lowest occurrence of this fauna is reported from a horizon 1,300 feet above the base of the Feing group (sample 224). The composition of the assemblage suggests Cenomanian age. Some of its species, particularly *Textularia washitensis* occur also in the shales with Cenomanian ammonites at Mingenda in the Wahgi valley and in "Stage 3" of the Chimbu-Wahgi section (see below p. 166). *Globotruncana* aff. *appenninica*, a single-keeled species of this typical Upper Cretaceous genus, with inflated chambers, appears to be a world-wide marker for Cenomanian. It has not been recorded yet from elsewhere in New Guinea.

2. Purari formation.—The foraminiferal fauna of the Purari formation is generally rather poorly preserved. It appears to be uniformly distributed throughout the sections exposed in Paw Creek (see Carey, 1944). The following preliminary determinations have been made:—

Rhizammina sp. (common).
Ammodiscus sp.
Haplophrammoides sp. (common).
Dorothia gradata (Berthelin) (common).
Lenticulina gaultina (Berthelin) (frequent).
Lenticulina sp.
Astacolus sp.
Vaginulina sp.
Planularia sp.
Marginulina spp.
Nodosaria sp.
Lagena apiculata Reuss.
Globulina sp.
Buliminella sp.
Gyroidina aff. *nitida* Reuss.
Epistomina sp.

The general composition of this fauna agrees with assemblages found in the upper part of the Lower Cretaceous (Aptian or Albian). It resembles the foraminiferal fauna of the lower part of the Feing group; *Pleurostomella* and *Globigerina* are however absent from the Purari fauna.

MOLLUSCA.

The Mollusca of the Feing Group.

Pseudavicula sp.

Material.—Numerous valves (about 20-30), both right and left, mostly preserved as internal and external casts, with fragments of the shell attached.

Occurrence.—Dark shale of the Feing group (samples 210, 239), about 500 feet above base, with *Parahibolites blanfordi.*

Description.—Shell small, suborbicular, inequilateral, compressed, test very thin, often wrinkled by rock pressure. Umbo small, very little projecting, sub-central in relation to the greatest length of the valve. Dorsal margins straight, antero-dorsal margin long, slightly convex, forming a blunt angle with the broadly rounded ventral and posterior margin. Posterior auricle large, with a distinct dorsal rim, posterior margin convex. Surface covered with numerous blunt radial ribs, unequal in width, with narrow smooth interspaces.

The large size of the anterior portion of the shell appears to be a distinctive feature of these fossils but the available material is not well enough preserved to permit a more detailed description and identification.

Age.—Upper Albian.

Inoceramus sp.

Fragments of large shells representing an undetermined species of *Inoceramus* occur in the type area of the Feing group (samples 212, 239, 209) and also in the Palmer River area, 20 miles east-south-east (Chawner coll., samples 14, 121).

Turrilites aff. **costatus** Lamarck.

Material.—A distorted and partly crushed fragment of a single whorl.

Occurrence.—Feing group, basal part of Narin formation (Chawner coll., Palmer River, sample 115).

Remarks.—This fragmentary specimen resembles *T. costatus* Lamarck and also *T. acutus* Passy which according to Spath is connected with Lamarck's species by innumerable passage forms. *T. costatus* is known from the Cenomanian of Europe, North Africa, Palestine, Zululand, Madagascar and Southern India (Middle Utatur group). *T. acutus* is known from the Cenomanian of France, Northern Germany, North Africa and Natal and the "Vraconnian" of Mexico.

Parahibolites blanfordi (Spengler).

(Pl. VI., figs. 10*a-c*.)

Belemnites fibula (pars). Blanford, 1861, The foss. Cephalop. of the Cret. rocks of S. India. Pal. Indica., ser. 1, p. 3, pl. 1, figs. 14, 16-19, 24-34, 41; pl. 2, figs. 5, 6 (non *B. fibula* Forbes).

Belemnites n.sp., Kossmat, 1897. Rec. Geol. Survey of India, vol. 30, pt. 2, p. 87.

Pseudobelus blanfordi Spengler, 1910. Beitr. z. Pal. u. Geol. Oesterr.-Ung. u.d. Orients, vol. 23, H.3, p. 155, pl. 12, fig. 6, pl. 14, fig. 6.

Parahibolites blanfordi, Bülow-Trummer, 1920. Fossilium Catalogus i., pt. 11, p. 164.

Material.—A single well-preserved rostrum.

Occurrence.—Dark shale of Feing group, 500 feet above base, with *Pseudavicula* sp. and smaller foraminifera (sample 210).

Description.—"Guard elongated, compressed, columnar or lanceolate, acutely pointed behind on the frontal aspect. Section oval or oblong. Ventral surface evenly rounded with a very short furrow at the anterior extremity. Sides more or less flattened, having in some specimens a shallow sulcation, most distinct in front; marked very distinctly with a double vascular impression, which generally extends the whole length of the guard. The alveolar cavity very acute, and extending in all the specimens examined, considerably more than half the length of the guard. It is somewhat eccentric, particularly in very compressed specimens." (Blanford).

Remarks.—The laterally compressed shape, short ventral groove, and well-developed straight lateral lines over the whole length of the Feing specimen agree well with the species described by Blanford as *B. fibula.*

Age.—This species is known only from the Lower Utatur group of southern India, zone of *Stoliczkaia dispar*, Upper Albian ("Vraconnian").

The Mollusca of the Purari Formation.

A rich fauna of mollusca was obtained by Carey in the area occupied by the sediments of the Purari formation. The majority of samples taken from outcrops contain only smaller foraminifera and other microfossils (holothurian plates, ophiuran vertebral ossicles, ostracodes) and undeterminable echinoid remains. One bed in the upper part of the exposed section is rich in *Exogyra* aff. *couloni* and contains also *Ostrea* sp. and a small number of undetermined lamellibranchs and gastropods. Numerous pebbles and boulders of a blue, hard sandy limestone or calcareous sandstone collected in the creeks in this area are extremely rich in mollusca. This "molluscan bed" has not been seen in situ in the type area of the Purari formation (Paw Creek). Carey (1944) states that "the horizon of the molluscan material cannot be very different from that of the *Exogyra* bed."

Owing to limitations of available time and facilities the present writer has not yet been able to carry out a complete study of this rich fauna. A list of a few distinctive forms follows, and the most abundantly occurring species among them is described, together with the *Exogyra* and a belemnite, a perfect specimen of which was found in a loose block of sandstone.

The fauna includes *Lingula* cf. *subovalis* Davidson, *Trigonia* sp., *Cardium* sp. *Ptychomya* sp., *Pseudavicula papyracea* Etheridge, *Ostrea* sp., *Mytilus* sp., *Nerinea* sp., *Alaria* (*Anchura*) cf. *wilkinsoni* Etheridge, ?*Praestriaptychus* sp., *Tetrabelus macgregori* n. sp.

1. **Pseudavicula papyracea** R. Ethridge, jun.

(Pl. VI., fig. 11.)

"Undetermined bivalve", R. Etheridge, jun., 1892. Geol. Pal. Queensland, p. 482, pl. 21, fig. 14.

Pseudavicula papyracea, R. Etheridge, jun., 1907. Rec. Austral. Mus., vol. 6, No. 5, p. 319.

Material.—Large numbers of more or less well preserved specimens.

Occurrence.—Abundant in calcareous sandstones rich in mollusca, Purari formation, Paw Creek, and Wabo Creek, Middle Purari valley (not found in situ). Similar forms occur also in "Stage 2" of the Chimbu-Wahgi section, Lower Wahgi valley (Noakes coll., sample 30).

Description.—"Shell suborbicular, delicate and fragile, compressed, posteriorly, alate, test very thin, papyraceous. Left valve convex in the umbonal region, with a sharply-pointed rather elevated umbo. Right valve more depressed than the left and the umbo inconspicuous. Dorsal margins on both sides straight, those anterior to the umbo obliquely inclined, those on the posterior straight; anterior ends small, the margins rounded; posterior alations small, flat, the margins rectangular. Sculpture of microscopic concentric lines." (Etheridge 1907.)

Measurements.—In the majority of examined specimens the height varies between 15 and 30 mm.

Remarks.—The characters of the most abundant lamellibranch of the Purari molluscan fauna appear to agree well with Etheridge's description. The left valve, not figured by Etheridge, resembles his second "undetermined bivalve" (l.c. 1892, pl. 21, fig. 16) although as stated by this author, the umbo is further removed from the anterior margin in the present species. In some specimens the concentric growth lines are fairly well marked. The present writer has been unable to compare his material with Etheridge's type specimens.

2. **Exogyra** aff. **couloni** (Defrance).

Material.—Numerous specimens, mostly casts with fragments of the shell preserved. Left valve attached to various molluscan shells.

Occurrence.—A distinctive calcareous "*Exogyra*-bed," about 10 feet thick, in the upper part of the Purari formation; Paw Creek area, middle Purari valley. (Samples 130-139.)

Remarks.—The present specimens, although abundant, are rather poorly preserved. They agree in general with the description of *E. couloni* given by H. Woods ("*E. sinuata* Sowerby," H. Woods, Palaeontogr. Soc., vol. 66, 1913, p. 395, pl. 61, fig. 13, text figures 194-214). The only noticeable difference is the absence of any concavity of the posterior margin of the shell. It is generally straight. None of the specimens seen is nearly as large as the largest European representatives of the species (average length about 5 cm.).

Age.—*E. couloni* is a common fossil of the Lower Cretaceous. An *E.* cf. *couloni* was reported by Piroutet from the Lower Cretaceous (Moindou) of New Caledonia.

3. **Tetrabelus macgregori** n. sp.

(Pl. VI., figs. 12*a-b*.)

?*Belemnites* sp., R. Etheridge, jun., 1902. Mem. Geol. Survey N.S.W., Palaeont. Nr. 11, p. 46, pl. 9, figs. 3-5.

?*Tetrabelus* sp., F. W. Whitehouse, 1924. Geol. Mag., vol. 59, p. 413ff.

Material.—One large well-preserved rostrum, one small rostrum of similar type, and several fragments which are enclosed in hard rock.

Occurrence.—Tuffaceous and calcareous sandstones of the Purari formation, Paw Creek, Middle Purari valley. Holotype from sample 186, Paw Creek, not in situ. Also in boulders of molluscan sandstone from Paw Creek (samples 65, 107, 109) and Wabo Creek (sample 20).

Description.—The holotype of this species was examined by Dr. F. W. Whitehouse who recognized it as a new species of *Tetrabelus*. Whitehouse (l.c., 1924) established this genus for "clavate belemnites provided with dorso-lateral grooves and lateral lines, having, in addition, independent ventro-lateral grooves. Alveolus normal." In the new species the rostrum is strongly constricted in the post alveolar region and dorso-ventrally compressed, particularly where it expands again to its greatest width. Dorso-lateral grooves well developed, prominent and deep, passing at about one-third of the length of the rostrum into the less conspicuous lateral lines, the connection being not straight but ventrally curved. The lateral lines continue nearly to the apex. Ventro-lateral grooves faintly developed in the alveolar region.

Measurements.—Length 100 mm., greatest width 13 mm., dorso-ventral diameter between alveolar region and zone of greatest width 9.3 to 9.6 mm., minimum width in alveolar region 9.8 mm.

Remarks.—The writer was unable to compare the new form with the original of Etheridge's unnamed belemnite from the Aptian of New South Wales. The two specimens appear to be very similar in size and shape but Etheridge's form contracts more rapidly toward the apex. According to Whitehouse it "shows a very long ventro-lateral groove converging towards the dorso-lateral near the apex". This is not the case in the Purari specimens. Whitehouse also states that "from the figure given by Etheridge the two grooves are of almost equal strength, the dorso-lateral however being possibly a little more prominent In *T. kleini* all grooves are of equal impress, while in *T. seclusus* the ventro-lateral is much more distinct than the dorso-lateral" From this description it appears that the new species is different from all known representatives of the genus. If Whitehouse's view of a "morphological progression" from *Dimitobelus*, without independent ventro-lateral grooves, through the known species of *Tetrabelus* is accepted, then the new species should be regarded as the most primitive form.

This species is named after Sir William MacGregor, explorer and administrator of Papua, who discovered the Cretaceous rocks on the Purari in 1894.

Stratigraphic Conclusions.

1. Fossiliferous Mesozoic Rocks of New Guinea.

The Mesozoic stratigraphy and fauna of Netherlands New Guinea were summarized by Zwierzycki (1928, 1931) in his explanations to the geological maps of that territory, and reviewed by Hövig (in: Klein 1937, pt. 2). E. R. Stanley published data on the Mesozoic rocks of the Territory of New Guinea (1923, pp. 30-31) and of Papua (1923A, pp. 25-27). Certain statements on this subject in Stanley's publications require critical comments in order to define more clearly the available data.

The age of the *Alveolina*-limestone on Mt. Wilhelmina in Netherlands New Guinea, which was mentioned by Stanley, is Eocene (Zwierzycki 1928, p. 29). The fossils reported by Richarz from the Torricelli Mountains as Cretaceous (Cenomanian) are Miocene. This was recognized by Schubert and again emphasized by Zwierzycki (1928, p. 25). The "Cretaceous *Alveolina*-limestones" of the Finisterre Mountains on the North Coast of New Guinea are actually known to be Miocene, including Middle Miocene

at the genotype locality of *Flosculinella* Schubert (Kabarang River near Cape Rigny). Stanley was probably misled by references to "chalky" limestones. The *Globigerina*-limestones in the Njau plain on the border between Netherlands New Guinea and the Mandated Territory were reported by Schubert to contain Cretaceous foraminifera, but he pointed out that these fossils are possibly not *in situ*. The "cherts containing *Actinacis sumatrensis*" described by Gregory and Trench from pebbles collected in the Fly River have not been found by Osborne on his recent expedition to the Fly River headwaters. The range of the genus *Actinacis* is now known to extend into the Oligocene. The occurrence of fossiliferous Upper Cretaceous "at the head of Karova Creek, a few miles east-north-east of Kerema" has not been confirmed in the course of geological exploration carried out in this area on behalf of Australasian Petroleum Company. Some confusion concerning the locality of Stanley's specimen, which appears to have been lost subsequently, is suspected by the present writer. All fossils found by Everill "in about latitude 7° south on the Strickland River" came from pebbles and the inclusion of this area in the Mesozoic on the geological map of Papua is not justified. Recent work by Noakes revealed evidence for Neogene age of limestones in Northern New Britain for which Cretaceous age had been assumed on lithological grounds and on the evidence of a gastropod cast determined as "*Actaeonella*" (probably *Oliva* sp.).

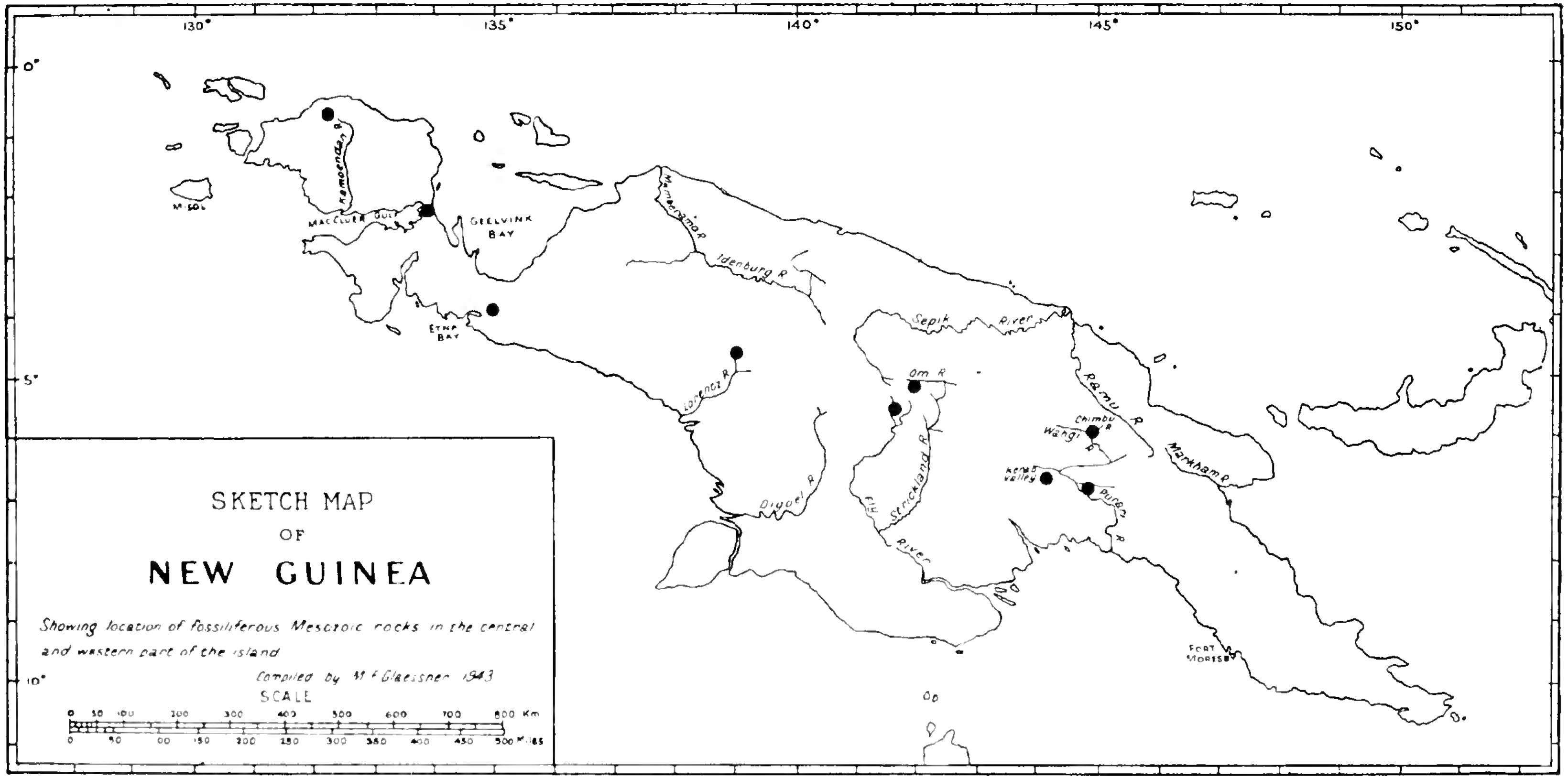
The known pre-Tertiary basement in a wide zone, including the northern coastal ranges of New Guinea, the Bismarck Archipelago, the Solomon Islands, New Hebrides, Fiji, and Tonga consists entirely of metamorphic or plutonic rocks.

The known occurrences of fossiliferous Mesozoic rocks in Papua and the Territory of New Guinea include the headwaters of the Fly, Strickland, and Sepik rivers, some of the country north of Mt. Murray (Kerabi Valley), and on the Middle Purari River, the Wahgi Valley (see map), and areas in the Owen Stanley Ranges.

2. The Age of Kuabgen Group.

The fauna with *Buchia malayomaorica* and *Belemnopsis gerardi*:—Abundant occurrence of *B. gerardi* and similar forms, together with large *Inoceramus* is a characteristic feature of Oxfordian strata in the eastern part of the Sunda archipelago. The middle part of the Jurassic sequence on the upper Fly river is therefore considered as Oxfordian. This agrees also with the distribution of *Buchia malayomaorica* at the numerous localities from which this species has been recorded. The same age is assigned to the *Buchia malayomaorica*-horizon of the Chimbu-Hagen area, about 2,700 feet above the base of the Mesozoic section described by Noakes. Pebbles with Oxfordian fossils are known from the Sepik river.

The stratigraphic range of the Kuabgen group:—The oldest Jurassic fossil found in the Fly River section is *Grammatodon virgatus,* which ranges from the *macrocephalus*-beds (Upper


130°
135°
140°
145°
150°
0°
5°
10°
Kamoendan R
M. SOL
MACCLUER GULF
GEELVINK BAY
ETNA BAY
Mamberamo R
Idenburg R
Lorentz R
Digoel R
Sepik River
Om R
Strickland R
Fly River
Ramu R
Chimbu R
Wahgi R
Kerab Valley
Purari R
Markham R
PORT MORESBY
SKETCH MAP
OF
NEW GUINEA
Showing location of fossiliferous Mesozoic rocks in the central and western part of the island
Compiled by M. F. Glaessner 1943
SCALE
0 50 100 200 300 400 500 600 700 800 Km
0 50 100 150 200 250 300 350 400 450 500 Miles

[Page 163.

Bathonian or Callovian) to the *cordatum*-zone (Upper Divesian-Lower Oxfordian). While this range gives no direct evidence of pre-Oxfordian age of the lower Kuabgen beds, the reported occurrence of this species in lower zones of the Upper Jurassic may be significant. Callovian fossils are well known as pebbles from the rivers of the Central Highlands of New Guinea, including the Strickland and Sepik. The species *Meleagrinella braamburiensis* and *Belemnopsis* cf. *indica* from a bed below the *Buchia*-horizon are forms which apparently did not range above the lower Oxfordian. This again agrees with the assumption that the base of the Oxfordian may be above the horizon of *Grammatodon virgatus.* Callovian age of this part of the Kuabgen group is therefore not unlikely. There is little evidence of Middle Jurassic (Bathonian-Bajocian) in this part of New Guinea. It is confined to a report of *Stephanoceras* from the Strickland pebbles.

The upper part of the Kuabgen group contains only *B. gerardi.* The age of this part of the section cannot be determined directly. The occurrence of uppermost Jurassic ammonites in the Sepik pebbles, to which a record of perisphinctids of "uppermost Jurassic or lowest Cretaceous" age determined by Reeside from beds outcropping in the Om River (Strickland headwaters) can now be added (see Osborne, 1944, p. 132) indicates the probability of Tithonian occurring in the area. No definite index fossils of uppermost Oxfordian or Kimmeridgian age have been recorded from the Indo-Pacific region.

The age of the Kuabgen group is therefore Upper Jurassic (possibly Callovian to Tithonian). Some Middle Jurassic may also be present in the vicinity of the Sepik-Strickland divide, in view of the recorded occurrence of *Stephanoceras.*

3. The Age of the Feing Group.

The age of the beds with *Parahibolites blanfordi*:—The lower part of the Feing group is characterized by the occurrence 500 feet above the top of the Jurassic of a belemnite known from the Lower Utatur group of Southern India (Upper Albian, *dispar*-zone). The character of the foraminiferal assemblage found in the lower Feing agrees with this age. The lowest part of the Cretaceous section is represented by sandstones from which a loose block containing fragments of belemnites, lamellibranchs, crinoids and echinoids (sample 209) is believed to be derived. As the belemnites could not be freed from the matrix, they remain, unfortunately, undetermined. It is not unlikely that the genus *Parahibolites* is represented among them. A more calcareous portion of this sample shows some slight resemblance with the molluscan bed of the Purari formation. This sandstone block contains pebbles some of which are evidently derived from

the Kuabgen group. A large pebble of black siliceous shale found loose at the same locality contains several specimens of a canaliculate belemnite.

The age of the beds with *Globotruncana* aff. *appenninica*:—The Lower Cretaceous lower part of the Feing group passes gradually upward into more argillaceous beds containing a rich assemblage of smaller foraminifera, including Upper Cretaceous forms such as single-keeled *Globotruncana* with inflated chambers (*appenninica*-type), *Bulimina reussi, Pleurostomella subnodosa,* together with other species known from Albian and Cenomanian (*Gyroidina nitida, Textularia washitensis, T. rioensis*). *Inoceramus* and *Turrilites* cf. *costatus* occur together with this assemblage which has a distinctly Cenomanian character.

4. The Age of the Purari Formation.

The Cretaceous beds in the hills north of the Purari River, about 120-136 miles up its course, were discovered by Sir William MacGregor in 1893-4.

Only a preliminary examination of the fossils collected at the same locality by Carey in 1940 has been carried out. The foraminiferal fauna indicates approximately Aptian to Albian age. The fauna of the molluscan bed contains elements related to species from the Tambo and Roma beds of eastern Australia (Upper Albian, Aptian), such as *Lingula* cf. *subovalis, Pseudavicula papyracea, Alaria* cf. *wilkinsoni, Tetrabelus macgregori,* but in the absence of ammonites it is impossible to assign it to definite zones. The Lower Cretaceous affinities of the fauna are strengthened by the occurrence of *Exogyra* cf. *couloni* and of further mollusca resembling Australian Lower Cretaceous forms which, however, have not yet been examined in detail. Most of the larger fossils appear to be derived from the upper 1,000 feet of the Cretaceous sequence which is transgressively overlain by Eocene. If this part of the Purari formation is assigned to the Aptian or Albian, the question arises whether the lower part of the sequence could represent earlier stages of the Lower Cretaceous. The uniform character of the foraminiferal assemblage throughout the sequence makes a very great age difference between the higher and lower beds unlikely.

5. Correlation of the Purari, Feing, and Kuabgen Strata.

The Purari formation cannot be considered as an equivalent of the entire Feing group. It is possible, however, that the upper part of the Purari formation corresponds to the lower part of the Feing. The conspicuous molluscan bed of the Purari formation has been reported from a number of widely scattered localities.

A typical specimen was obtained by Mr. Ethell, Patrol Officer, in the course of a patrol between Keuri (Sarugi) Valley and Lake Tebera, 20 miles west of the type locality on the Purari. One hundred and eighty miles further west, on the Strickland River, at the highest point reached by Everill in 1885, G. Barrow collected a pebble of a bluish-green calcareous sandstone with abundant mollusca. A similar rock was found in 1939 by the late L. Vial, then Assistant District Officer, in the Wahgi Valley west of Mingenda.

A detailed study of the Lower Tertiary and Mesozoic sequence in the lower Chimbu and Wahgi Valleys, which was carried out by L. C. Noakes in 1939, proved the existence of a series of sediments over 22,000 feet thick, " in which deposition extends conformably from about Jurassic to Eocene time." (This and the following quotations are taken from an unpublished report by L. C. Noakes, dated July, 1939.) Noakes divided this sequence, which consists predominantly of shales and mudstones, with some sandstones, into five " stages ". The lower two and part of " Stage 3 " are of interest in conjunction with the present investigation. A dark-red to chocolate shale with *Buchia malayomaorica* and *Inoceramus* was found in " Stage 1 " about 2,700 feet above the base of the section. This " stage " consists mainly of slightly calcareous and siliceous shales.

The second " stage " is characterized by an abundance of tuffaceous sandstones most of which are laminated or interbedded with shale. A volcanic agglomerate was taken by Noakes as marking the base of this " stage ". Most of the samples are unfossiliferous but fragments of *Ostrea,* a *Pseudavicula* and plant remains occur in the upper 1,500 feet (samples 28-36), suggesting a correlation with part of the Purari formation. " Stage 3 " consists mainly of shales and mudstones. " The Mingenda ammonite horizon is considered to lie in the lower half of this stage " (Noakes). This bed, which is exposed on Mingenda Mission aerodrome, contains well-preserved ammonites and *Inoceramus* resembling those reported by E. R. Stanley (1923, p. 26) from the Kerabi Valley north of Mt. Murray. These appear to be approximately of middle Cenomanian age (Whitehouse 1926, p. 279. The writer was informed by Dr. Whitehouse that various published references to a fauna " from the Strickland River " are based on Stanley's specimens). The Mingenda bed and its equivalents in " Stage 3 " contain also *Textularia washitensis,* a foraminiferal species known from the upper part of the Feing group.

The resulting correlations are shown in the following table:—

Table 1.—Correlation of Fossiliferous Mesozoic Strata in New Guinea.

		Fly River Area.	Strickland River Area.	Area between Strickland and Purari Rivers.	Wahgi River Area.	Purari River Area.
Cenomanian		(Transgressive Tertiary limestones) Feing Group (3,400 feet)		Kerabi beds (thickness and sequence unknown)	" Stage 3 " (6,500 feet)	(Transgressive Tertiary Limestones)
Lower Cretaceous	Albian					
	Aptian		" Fossiliferous Green-sand " (not known *in situ*)		" Stage 2 " (6,200 feet)	Purari Formation (5,000 feet, base not known)
	Neocomian				?	
Upper Jurassic		Kuabgen Group (4,000 feet)	Om river beds (thickness unknown)		" Stage 1 " (4,500 feet)	

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Explanation of Plate.

PLATE VI.

FIG. 1*a-b*.—*Grammatodon (Indogrammatodon) virgatus* (J. de C. Sowerby). Kuabgen Group (Upper Jurassic), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 252.)

FIGS. 2-4.—*Meleagrinella braamburiensis* (Phillips). Kuabgen Group (Upper Jurassic), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 210.) Fig. 2—right valve, figs. 3, 4—left valves.

FIGS. 5*a-b*, 6.—*Buchia malayomaorica* (Krumbeck). Kuabgen Group (Upper Jurassic, Oxfordian), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 215.) Fig. 5*a*—right valve, external view; fig. 5*b*—same valve, internal view; fig. 6—left valve, internal view.

FIG. 7.—*Buchia malayomaorica* (Krumbeck). Wahgi Series. "Stage 1" (Upper Jurassic, Oxfordian), Lower Wahgi River, New Guinea. (Coll. N. Noakes, sample 57.) Left valve, external view.

FIGS. 8, 9 *a-b*.—*Belemnopsis gerardi* (Oppel). Kuabgen Group (Upper Jurassic, Oxfordian), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 215.)

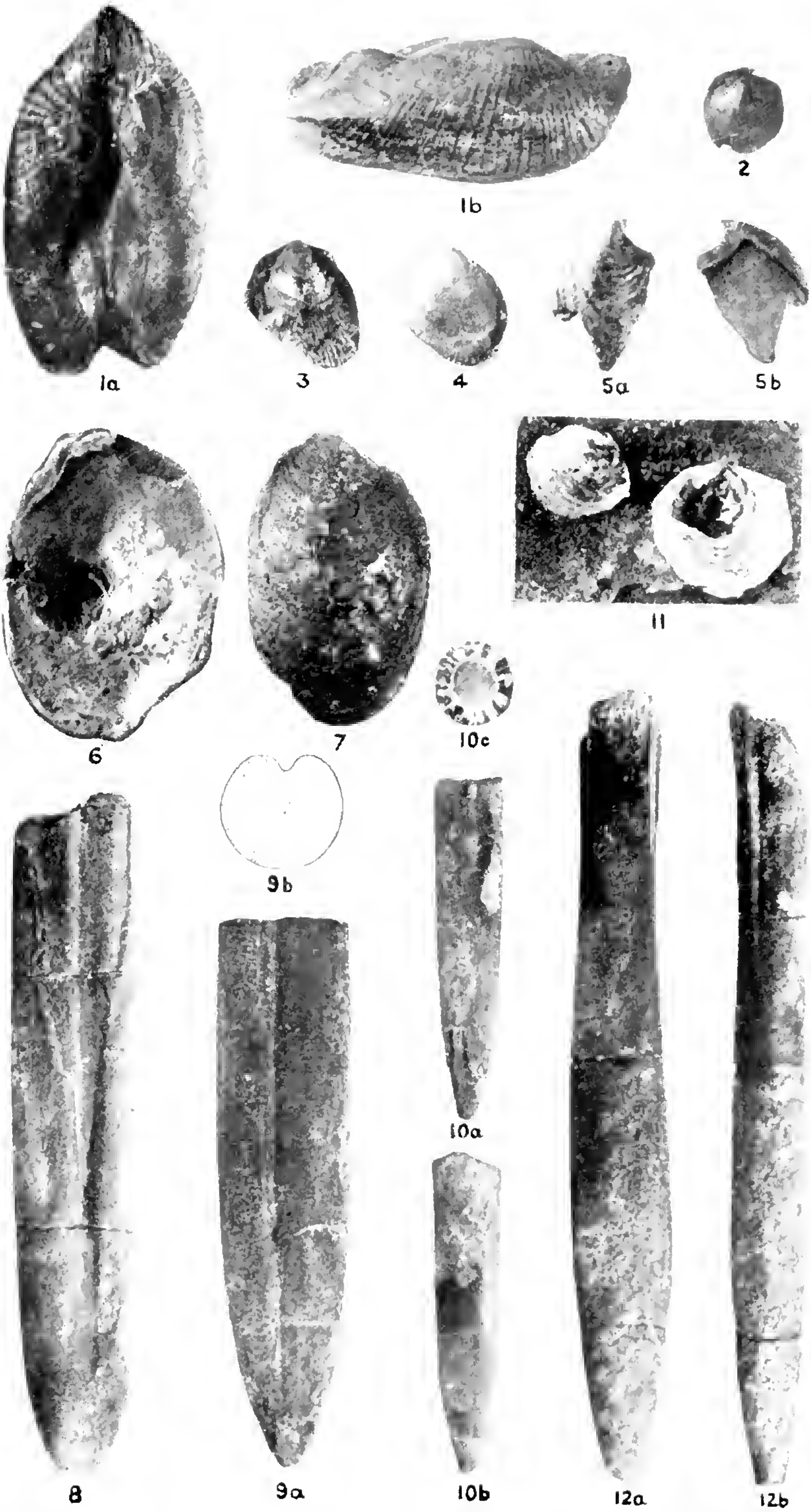
FIGS. 10 *a-c*.—*Parahibolites blanfordi* (Spengler). Feing Group, lower part (Upper Albian). Fly River Headwaters, Papua. (Coll. N. Osborne, sample 210). Fig. 10*a*—ventral view. Fig. 10*b*—lateral view. Fig. 10*c*—alveolar view.

FIG. 11.—*Pseudavicula papyracea* (R. Etheridge, jun.). Purari Formation (Aptian-Albian), Wabo Creek, Purari River, Papua. (Coll. S. W. Carey, sample 22.)

FIG. 12*a-b*.—*Tetrabelus macgregori* n.sp. Holotype. Purari Formation (Aptian-Albian), Paw Creek, Purari River, Papua. Coll. S. W. Carey, sample 186, Melbourne University, Geol. Department Reg. No. 1876).

Photographs by Miss M. L. Johnson, Melb. Univ. Geol. Dept.

All figures approximately natural size.


1a
1b
2
3
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9a
10a
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12a
12b

[PROC. ROY. SOC. VICTORIA, **56** (N.S.), PT. II., 1945.]

ART. XI.—*Trilobita of the Family Calymenidae from the Palaeozoic Rocks of Victoria.*

By EDMUND D. GILL, B.A., B.D.

[Read 9th December, 1943; issued separately 30th June, 1945.]

Summary.

Four new species of trilobites—*Calymene bowici*, *C. killarensis*, *Gravicalymene hetera*, and *G. kilmorensis*—are described, *Gravicalymene angustior* (Chapman) re-described, and notes provided on other forms. Descriptions and maps of new fossil localities are given. The bearing of these determinations on stratigraphy is discussed.

Introduction.

Trilobites of the genera treated in this paper are known in Victoria only from Upper Silurian and Lower Devonian rocks. They comprise the following species:—

Species.	*Age*	*Stratigraphical Series.*
Calymene bowiei sp. nov.	Lower Devonian	Yeringian
C. killarensis sp. nov.	Lower Devonian	Yeringian
Gravicalymene angustior (Chapman)	Lower Devonian	Yeringian
G. hetera sp. nov.	Upper Silurian	?Melbournian
G. kilmorensis sp. nov.	?Upper Silurian	?Melbournian
G. cf. *kilmorensis* sp. nov.	Upper Silurian	Melbournian
Flexicalymene sp.	?Upper Silurian	?Melbournian

The determinations of fossils in this paper supersede lists previously given (Gill 1938, 1939).

Systematic Descriptions.

Family CALYMENIDAE H. Milne Edwards, 1840.

Genus CALYMENE Brongniart, 1822.

Genotype **Calymene blumenbachi** Brongniart, 1822.

Chapman referred a trilobite from Moonee Ponds Creek, Melbourne, to the above genotype (Chapman 1914, p. 219; 1915, p. 166). The specimen, which consists of thorax and pygidium only, is in the National Museum (reg. No. 452), but as the cephalon is not present, a determination is not attempted. In the 1914 paper (p. 228) *C. blumenbachi* is also recorded from "Upper Yarra". This is apparently the same specimen as was later described as *C.* cf. *blumenbachi* (Chapman 1915, p. 166, Pl. XV., fig. 11). This specimen is in the National Museum, comes from Section 12, Parish of Yering (which in this case is "Flowerfield" Quarry—Gill, 1939), and is No. 1862 of the Geological Survey of Victoria collection. Unfortunately, the preservation is poor, and determination is not attempted. Chapman also recorded "*C.* cf. *tuberculata* Salter" from Kilsyth, near Croydon

(Chapman, 1907, p. 239; 1914, p. 228), which species has since been re-named *C. nodulosa* (Shirley, 1933, p. 53). This specimen (also housed in the National Museum) consists of a few segments of the thorax only, and a determination is not attempted. Selwyn (1855-6) and Smyth (1874, p. 34) record *C. tuberculata* from "Upper Yarra". This is probably the specimen in the National Museum (reg. No. 451) which is complete but ill preserved, and labelled as being from "Yering, Upper Yarra". The matrix suggests that it originates from "North of Lilydale". The specimen does not admit of precise determination by modern standards. "*Calymene* sp." has been recorded from numerous localities, but in most instances the specimens on which the determinations were based cannot now be traced.

Calymene bowiei, sp. nov.

(Plate VII., figs. 1, 2, 6.)

Type Material.—The internal cast of a cranidium and external mould of same (syntypes) in the National Museum, Melbourne (reg. Nos. 14504 and 14505), collected from fawn mudstone at Syme's Homestead, Killara (locality 33).

Age.—Yeringian Series—Lower Devonian.

Description.—Cephalon strongly convex; of the profile shown in fig. 1A. Glabella very convex, being raised well above the level of the fixed cheeks. Glabella much wider posteriorly than anteriorly, i.e., markedly bell-shaped in outline; does not overhang pre-glabellar field; projects well forward of the fixed cheeks. Posterior glabella lobes large, squarish in outline, and joined to the middle part of the glabella by narrow bridges which are lower in level than the lobe. The bifurcated furrows in front of the posterior lobes leave small protuberances or interlobes between the posterior lobes and the middle ones. The second or middle lobes are markedly smaller than the posterior ones. They are stumpy, but not flattened on the ends as in *C. killarensis*. Opposite the second lobes the fixed cheeks draw in towards the glabellar lobes to form buttresses, but these are not flattened on the tips as they are in *C. killarensis*. The anterior lobes are small, and consist only of dorso-ventral ridges on the sides of the main body of the glabella. There are no fourth lobes. Main body of glabella much higher than lobes. Eyes opposite middle lobes. "Antennary" pits occur in the floor of the axial furrows opposite where the fourth lobes usually appear. The axial furrows are deep, wide in front, and narrow behind the buttresses. Sutures much the same as in *C. killarensis*. The inner margins of the fixed cheeks run directly posteriorly till they draw in towards the glabella to form the buttresses opposite the middle lobes. From the buttresses to the intramarginal furrows the margins curve outwards to give the general bell-shaped appearance of the glabella region. The pre-glabellar field is short, shallow, and

recurved. The recurved margin is thin, and is directed forwards and slightly upwards (fig. 1A). Posterior intramarginal furrows broad; posterior walls a little steeper than the anterior walls. Occipital ring narrows at its extremities, which turn in towards the corners of the fixed cheeks. Genal angles rounded.

Length of holotype cranidium.—21 mm.

Width from genal angle to centre of glabella.—25 mm.

Comment.—The cephalon is tuberculated, but the precise nature of the ornament is not clear because of a layer of iron oxide over the external mould (paratype). *C. bowiei* is readily distinguished from the genotype (*C. blumenbachi*). The former has a bell-shaped glabella as against the squarish outline of the latter. In the genotype, the axes of the glabella lobes run transversely whereas in the new species they are directed forwards at an angle of about 20° to the transverse. The pre-glabellar field of *C. bowiei* (fig. 1A) is of the type of *C. aspera* (*vide* Shirley, 1936, pl. XXX., fig. 10) rather than that of *C. blumenbachi* (*vide* Shirley, 1933, pl. 1, fig. 3).

A few specimens have been noted in which the pre-glabellar field is more upturned than in the holotype. A sufficient range of specimens has not been procured yet, however, to enable one to determine whether this is a varietal difference, or one due to slight compression. The free cheeks are missing from the holotype, but

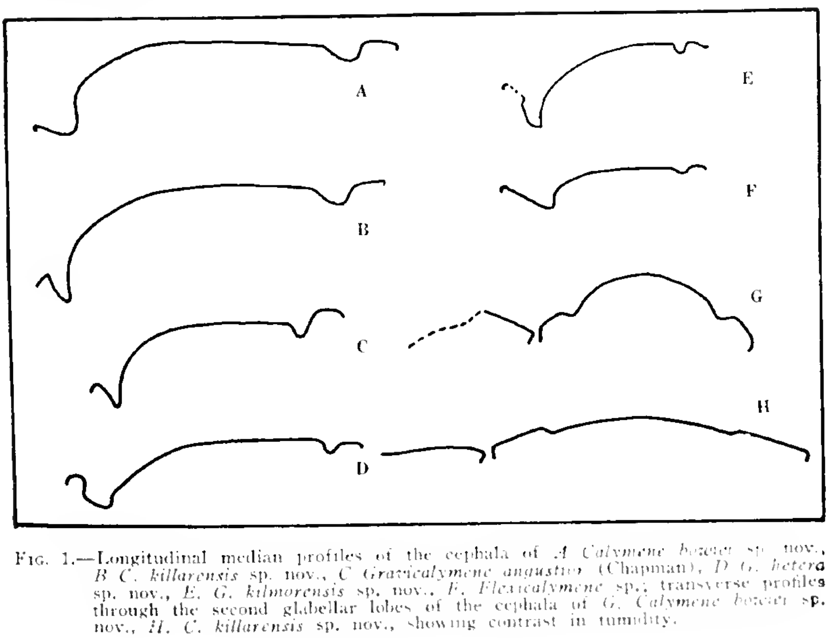

FIG. 1.—Longitudinal median profiles of the cephala of *A Calymene bowiei* sp. nov., *B C. killarensis* sp. nov., *C Gravicalymene angustior* (Chapman), *D G. hetera* sp. nov., *E. G. kilmorensis* sp. nov., *F. Flexicalymene* sp.; transverse profiles through the second glabellar lobes of the cephala of *G. Calymene bowiei* sp. nov., *H. C. killarensis* sp. nov., showing contrast in tumidity.

the general outline suggested by the cranidium is that of one tending towards a triangular shape. *C. bowiei* is named after Mr. Bowie, manager of the Killara estate, who directed the writer to the fossil locality from which the holotype was obtained. Specimens of *Beyrichia* and *Stropheodonta bipartita* (Chapman) occur on the same piece of rock as the type.

Calymene killarensis, sp. nov.

(Plate VII., figs. 8, 3, 4.)

Type material.—The internal cast of a cranidium (holotype) in the National Museum, Melbourne (reg. No. 14506), collected from the bluish-grey shale of Syme's Tunnel, Killara (locality 34).

Age.—Yeringian Series—Lower Devonian.

Description.—Cephalon moderately convex; of the profile shown in fig. 1B. Glabella broad (compare the genotype), overhanging the axial furrows; projects well forward past the fixed cheeks. Four lobes on each side, reducing sharply in size posterior-anteriorly. First lobes almost quadrangular, and connected with the main body of the glabella by bridges which are almost as elevated as the lobes themselves. The main body of the glabella, the bridges, and the lobes form a more or less continuous arch, and contrast in this respect with *C. bowiei* (figs. 1G, 1I). Second lobes elongated, and flattened on the ends, which are in juxtaposition with buttresses on the fixed cheeks; these second lobes are very noticeably directed forwards, making an angle of about 30° with a line joining the posterior margins of the eyes. Third lobes small, with strong furrowing behind, but shallow furrow in front. Fourth lobes consist of small bulges on sides of glabella, but there are definite furrows in front of and behind these lobes. There are small, rather sharp intermediate lobes between the first and second lobes. Large "antennary" pits lie in the axial furrows beside the fourth lobes. The preglabellar field is short, shallow, and recurved. The recurved part is thin, and projects outwards and upwards at an angle of over 45° with the horizontal (fig. 1B). Eyes opposite second lobes. Axial furrows moderately wide in front of the buttresses, and narrow behind them. Sutures begin just above genal angles and curve in towards the eyes, become almost parallel with the posterior margin of the cephalon when nearly to the eyes; from the eyes the sutures run straight forward to the anterior margin of the cephalon. Posterior intramarginal furrows broad; posterior walls a little steeper than the anterior walls. Occipital ring narrows at the extremities, which turn in towards the corners of the fixed cheeks. Genal angles rounded. Small pieces of the external mould obtained when clearing the fossil of matrix showed the cephalon to have been ornamented with a fine granulation.

Measurements of holotype.—Length of cranidium, 20 mm.; width of genal angle to centre of glabella, 25 mm.

Comment.—The examination of a number of specimens suggests that the axial furrows narrow slightly with age. The thorax is not known. Occasional pleurae are found but no complete thorax has yet been discovered, although the species is quite common at Killara, after which place the fossil is named. Pygidia are common, and probably belong to the same species. They are broad and very convex, with deep axial furrows. There are seven axial rings, and five pleural ribs, the last of which is parallel to the axis. The first four are bent backwards and are grooved distally for about half their length. The pygidium is closely and finely granulate. The cast and mould from which this description of the pygdium has been made, have been lodged in the National Museum (reg. Nos. 14511 and 14512).

The new species is comparable with *C. blumenbachi* which it resembles in its large sub-rectangular glabella. The chief differences are:—(1) The frontal lobe of the glabella does not overhang the pre-glabellar field as in *C. blumenbachi*. (2) The first lobes are even more quadrilateral in the new species than in the compared one. The second lobes, like those of *C. blumenbachi*, "when viewed from above show a papillate outline as if reaching out to the buttress on the fixed cheeks" (Shirley, 1933, p. 60), but much more so, and instead of being directed transversely, they are directed forwards as described. Judging from Shirley's figures (1933, pl. 1), the fourth lobe on our species is much better developed.

Occurrence.—*Calymene killarensis* has been collected by the author from Syme's Tunnel, Killara (loc. 34), and Syme's Homestead, Killara (loc. 33). A crushed specimen from the road cutting near the limestone quarry at Seville (loc. 38) probably belongs to this species. Chapman (1908, p. 269) records *Calymene* sp. from the Seville limestone (loc. 37). A plasticine impression of this mould shows that the specimen has buttresses opposite the second, and therefore belongs to the genus *Calymene sensu lato*. However, the preglabellar field is not preserved. These localities are shown on fig. 2, the numbers following on those previously used (Gill, 1940).

Genus GRAVICALYMENE Shirley, 1936.

Genotype **Gravicalymene convolva** Shirley, 1936.

When Shirley established the sub-genus *Gravicalymene*, the genotype was the only species known, and this came from the Upper Bala of Britain. Since then four other species have been referred to this genus, and another is now added in this paper.

When describing the Baton River (N.Z.) Beds, Shirley (1938) referred *Calymene angustior* Chapman to this genus, and also *C. australis* Etheridge and Mitchell, which he thought was almost certainly synonymous with the former. The present writer referred a new species, *Gravicalymene cootamundrensis* to this genus (1940), and later referred *Calymene malounkaensis* Mansuy to it, and suggested the elevation of Shirley's sub-genus to generic rank (Gill, 1942, p. 45).

Diagnosis of Genus *Gravicalymene*.—Calymenidae without papillate glabellar lobes, or buttresses on the fixed cheeks. Glabellar outline bell-shaped. Pre-glabellar field recurved with roll-like edge. Eyes opposite, or slightly anterior to, second lobes. Cephalic margin entire. Thorax (where known) of thirteen segments.

Range of Genus.—Ordovician to Devonian.

Occurrence in Victoria: Three species of this genus are known from Victoria, viz., *G. angustior* (Chapman), *G. hetera* sp. nov., and *G. kilmorensis*, sp. nov.

Gravicalymene angustior (Chapman).

(Plate VII., figs. 5, 10.)

Calymene angustior Chapman, 1915, pp. 164-166, Pl. XV., figs. 8-10.

Calymene australis Etheridge and Mitchell 1917, pp. 481-486, Pl. XXIV., figs. 1-3, ?4, 6-7.

Calymene (Gravicalymene) ?angustior Shirley, 1938, p. 487, Pl. XLIV., fig. 17.

Gravicalymene angustior Gill, 1942, p. 45.

The following is a re-description of this species from the holotype, and (where indicated) from the paratype presented by Chapman.

Carapace.—Measurements approximately 54 mm. long and 39 mm. wide. The carapace is damaged and so precise measurements are not possible. Widest across genal angles, and tapering to the posterior end of the pygidium.

Cephalon.—Sub-semi-circular and about a third length of carapace.

Narrow, bell-shaped glabella projecting a little beyond the fixed cheeks, with three distinct and a fourth incipient lobes on each side, reducing sharply in size posterior-anteriorly. Glabella tumid, elevated above fixed cheeks, and of the profile as drawn in fig. 1c. Pre-glabellar field (seen only in paratype) with roll-like thickened edge, which is somewhat more thickened opposite the axial furrows. Eyes slightly anterior to the middle of the second lobes.

As the anterior margin of the holotype has been destroyed, the following measurements to give the proportions of the cephalon are taken from the paratype. However, the genal angles of the paratype are obscured by matrix, and right free cheek is displaced. There has been a slight oblique crushing of the cephalon.

Length of paratype cephalon, 14·5 mm.

Width of paratype cephalon, 30 mm.

Length of glabella, 10 mm.

Width of glabella across third lobes, 7 mm.

Width of glabella across first (posterior) lobes, 10 mm.

A hypotype (Pl. VII., fig. 5), consisting of a cephalon (National Museum, reg. No. 14507), is now added, providing the following features:—Eyes situated about a quarter of the distance from the axial furrows to the margin of the free cheeks. Genal angles widely rounded. Free cheek suture commences in middle of the genal "angle", and proceeds to a point level with the posterior margin of the eye and half way between the margin of the free cheek and the eye, then proceeds to the posterior margin of the eye. From the anterior margin of the eye the suture proceeds to the anterior border of the cephalon with a slight outward curve. Cephalon finely granulated with granules of different sizes (this is also seen in the paratype). The hypotype is from Ruddock's Quarry (location 20).

Thorax (described from holotype).—Consists of thirteen segments. Axis approximately semi-circular in cross-section, and elevated well above the pleural areas. The axial rings have a prominent knob on each side of the axis. The axis with these knobs occupies a third of the width of the thorax. Pleurae fairly flat until at about three-quarters of their length from the axis, where they are bent sharply downwards. Each pleuron is deeply grooved. The free ends of the pleurae are rounded and curled forwards a little.

Pygidium (described from holotype).—As in the thorax the axial area is elevated well above the pleural areas. The axis tapers back evenly and carries six axial rings. The pleural ribs are streamlined backwards and are grooved distally for a little more than half their length. Well-marked furrows occur where the pleural areas join the axis.

Comment.—*Gravicalymene angustior* is very much like, and therefore presumably closely related to *G. cootamundrensis*, with which it differs in the following points:—

1. The cephalon is semi-circular with widely rounded genal angles in Chapman's species, whereas the compared species has a sub-quadrilateral cephalon with much less rounded genal angles. The cephalon is very convex in the former, and flat in the latter.

2. The free cheeks are wide, and the eyes near the glabella in Chapman's species, whereas in the compared species the free cheeks are narrow, and the eyes nearer the outer margin of the cephalon.

3. The carapace is much smaller and narrower in *G. cootamundrensis* than in *G. angustior*.

Chapman's species has obvious affinities with *G. interjecta* (Corda) of Étages F and G in Bohemia (Barrande, 1852, p. 570). *G. angustior* has a different pre-glabellar field and general profile; the trifurcate furrow between the first and second lobes described in *G. interjecta* is not present. It is interesting to note this link with the Bohemian facies in Europe. *G. angustior* also appears to be comparable with *G. malounkaensis* (Mansuy) from Indo-China (Mansuy, 1916, Pl. IV., figs. 4*a-c*). Shirley (1938) included *Calymene australis* (Etheridge and Mitchell) in the synonymy of *G. angustior* and commented (p. 487), "From an examination of the figures and description of *C. australis* (Etheridge and Mitchell), the New Zealand material appears to be identical: the authors specially mention the thickened margin of the pre-glabellar field and the lack of buttresses on the fixed cheeks. They also express a doubt whether their species is really separable from *C. angustior* of Chapman." The new data for *G. angustior* given in this paper (the nature of the genal angles and facial sutures) may be paralleled by Etheridge and Mitchell's fig. 2, Plate XXIV. In the synonymy given above, figure 4 on Etheridge and Mitchell's Plate XXIV. is questioned because it appears to have a sub-quadrilateral cephalon reminiscent of *G. cootamundrensis*. It is hoped to clarify the relationships of these species after the war when the types become available again.

Chapman (1915, p. 166) records this species from reddish sandstone in the "Range on E. side of commonage, Kilmore". This specimen is in the National Museum (the number 1208 is printed on it in red paint), and is described hereunder as *Flexicalymene* sp.

Etheridge (1899) records "*Calymene*" from Cooper's Creek, Gippsland. This fossil (Geol. Survey No. 178) has suffered compression, but no doubt belongs to *G. angustior*. No. 174 was determined by Etheridge as "*Calymene* sp.", but was retained for further study according to the note in the G.S.V. register. It is

therefore presumably still in the Australian Museum, Sydney. The G.S.V. register states that No. 178 now figured (Plate VII., fig. 10), is the same as No. 174.

Occurrence.—*Gravicalymene angustior* is known in Victoria from the following localities:—Cooper's Creek, Walhalla; Ruddock's Quarry (loc. 20); Ruddock's Corner (loc. 21); and North of Ruddock's (loc. 39). Figure 2 shows the exact situation of the three last-named localities. The species has also been recorded from the Australian Capital Territory (Woolnough, 1939), but the specimen has not been examined by the writer.

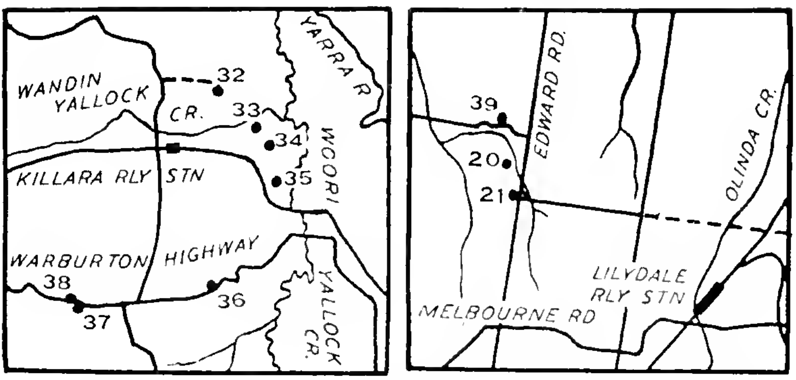

FIG 2.—Fossil localities of the Killara District and north-west of Lilydale.

Gravicalymene hetera, sp. nov.

(Plate VII., fig. 12.)

In the National Museum, Melbourne, (reg. No. 14508), there is a cranidium in bluish-grey, indurated, fine-grained sandstone from Kilmore East, presented by L. C. Parker, Esq., on 12th July, 1924. This fossil has been selected as the holotype for *G. hetera*, to which also should be referred the fossil figured by Chapman (1915, Pl. XV., fig. 10) from locality "Bb20, Kilmore Creek, north of the special survey." The holotype has been distorted a little by lateral pressure.

Description.—The fossil is near *G. angustior*, but differs in the following respects:—

(1) The pre-glabellar field is conspicuously wider and deeper than in *G. angustior*; the rolled "lip" is thinner and sharper than in the compared species.

(2) The glabella does not extend forward as far as it does in *G. angustior*, nor is it elevated high above the fixed cheeks as in that species. The profile is given in fig. 1b. The new species has

fourth incipient lobes as in *G. angustior,* but the "antennary pits" appear to be placed further forward. The measurements of the holotype are:

Length of cephalon, 14 mm.

Width from genal angle to centre of glabella, 20 mm.

Comment.—The Australian species of *Gravicalymene* form a compact group suggesting local evolution of the species. The occurrence of *G. angustior* in the Lower Devonian of New Zealand (Shirley, 1938) suggests some shallow sea connexion with that area as these trilobites show by their structure, the lithology in which they occur, and the fauna with which they were associated, to be of littoral habitat. The occurrence of *Gravicalymene* in Indo-China is interesting as suggesting connexion with that area.

Gravicalymene kilmorensis, sp. nov.

(Plate VII., fig. 9.)

Type Material.—The internal cast of a cranidium (holotype) in the National Museum, Melbourne, reg. No. 14509, from Kilmore East, presented by G. L. Pentreath, esq., 12th July, 1924. The matrix is a bluish-grey, fine-grained, indurated sandstone.

Description.—Cephalon shorter in proportion of width to length than *G. angustior.* Glabella bell-shaped and squat, with three distinct lobes and incipient fourth lobe on each side reducing sharply in size posterior-anteriorly; does not overhang pre-glabellar field; front of glabellar approximately level with forward extensions of fixed cheeks. Axial furrows very open and wider anteriorly than posteriorly. Pre-glabellar field recurved with small subsidiary ridge on roll-like edge. Profile as in fig. 1E. Edge of pre-glabellar field not thickened opposite axial furrows as in *G. angustior.* Eyes opposite second lobes, and much nearer axial furrows than margin of cephalon. Free cheek sutures pass more directly to the posterior margin of the eye than they do in *G. angustior.* Thorax and pygidium unknown.

Comment.—*G. kilmorensis* differs notably from *G. angustior* in (1) the squat proportions of the glabellar; (2) the wide axial furrows; (3) the presence of a subsidiary ridge on the pre-glabellar field, and its lack of thickening opposite the axial furrows; (4) the straighter course of the post-ocular part of the free cheek sutures.

The fossil is decorticated, leaving no indication of the nature of the surface ornament (if any). It is named after the town in the vicinity of which it was collected.

The generic position of this fossil presents an interesting problem. *Gravicalymene* has no subsidiary ridging on the pre-glabellar field according to the original diagnosis of the genus. The pre-glabellar field of the holotype of *G. kilmorensis* was slightly damaged immediately in front of the glabella when the specimen was being cleared of its matrix. However, the nature of the profile, as shown in fig. 1E, is still clear to one side of this point. Shirley's *Gravicalymene* and *Flexicalymene* closely approximate to one another. The description "Thorax 13 segments; glabella outline bell-shaped; pre-glabellar field recurved; axial furrows slightly contracted at each glabellar furrow" would apply equally to the above two genera according to Shirley's diagnoses. The only distinguishing feature in such an instance would be "recurved without subsidiary ridging" as against "recurved with roll-like edge". The fossil now described as *G. kilmorensis* has a recurved pre-glabellar field, but with a flattened slope as shown in the profile. *Diacalymene* (*vide D. drummockensis* in Shirley, 1936, p. 391) is characterized by the development of a subsidiary ridge in the pre-glabellar field, but the new species cannot be referred to *Diacalymene* as that genus possesses papillate second lobes. Shirley states (1936, p. 392) that such features as the character of the pre-glabellar field "must be used with caution and only in combination with other characters of the skeleton". Because of its strong affinities with species of *Gravicalymene*, our new species is doubtless best accommodated in that genus.

Gravicalymene spp.

(1) *Gravicalymene* cf. *kilmorensis*, sp. nov. A specimen in the National Museum (reg. No. 14510) from the Moonee Ponds Creek (Melbournian), collected by Mr. Spry, 5/10/22, belongs to the genus *Gravicalymene* (Pl. VII., fig 7). It is not sufficiently well preserved to make determination certain, but it is probably *G. kilmorensis*, sp. nov.

(2) From Locality 9, allotment 10, Parish of Redcastle, Dr. D. E. Thomas collected specimens of *Gravicalymene* (Geol. Surv. reg. Nos. 38006, 38007, 37974–37989) which belong, apparently, to yet another species. The great thickness of the rolled edge on the pre-glabellar field is a notable character. The material is not considered good enough on which to erect a new species.

(3) Two specimens of a species of *Gravicalymene*, very much like *G. angustior*, have been collected by the writer from Syme's Tunnel, Killara (loc. 34). However, the glabella stretches further forward than in the species named, the edge of the pre-glabellar field is thinner and sharper, and in size they are very

much smaller. *Calymene* (*sensu lato*) is common at this locality, but the above are the only two specimens of *Gravicalymene* yet found in the district.

Flexicalymene sp.

(Plate VII., fig. 11.)

Chapman (1915) referred a trilobite from reddish sandstone from " range on east side of Reserve of Commonage, Kilmore " to *G. angustior.* This fossil was collected by the Geological Survey in 1903, and is now housed in the National Museum (reg. No. 1208). The specimen is an exfoliated cranidium with a short glabella much narrower in front than behind. The glabella is produced forward of the fixed cheeks. The very wide and high pre-glabellar field is the most conspicuous character of this fossil. The cephalon is 11 mm. long, and the pre-glabellar field occupies 3 mm. (more than a quarter) of the length. The pre-glabellar field is directed forwards and upwards at an angle of 25°–30° to the horizontal. The profile is as shown in figure 1F. The anterior edge of the pre-glabellar field is rounded, but without the " draught-stopper " edge so characteristic of *Gravicalymene.* Like *Gravicalymene* and *Flexicalymene* this fossil has no buttresses opposite the glabellar lobes, and the fixed cheek margins draw in slightly opposite the inter-lobal furrows.

The main features of this form are distinct, and indicate it to be a new species, but the present specimen is scarcely good enough to be made into a holotype. This is the first record of this genus from Australia. Shirley described *Flexicalymene* as a sub-genus, and elsewhere it has been raised to generic status. This lead is followed here, but it is noted that *Flexicalymene* and *Gravicalymene* closely approximate to one another, and that the differences between these genera are not as great as the differences between others of the sub-genera proposed by Shirley.

Stratigraphical Considerations.

The genera *Gravicalymene* and *Flexicalymene*, which are closely related, were described originally by Shirley from the Ordovician of Great Britain (Llandeilo and Bala Beds). Both genera are now known from the Silurian. The former genus is also known from the Lower Devonian, and the latter from beds which are either high in the Silurian or low in the Devonian sequence. The range in time of these genera has therefore been considerably extended.

Another point of interest is the geographical distribution of some of these species. *Gravicalymene angustior* has been recorded from both Australia and New Zealand. A related species has been recorded from Cootamundra, New South Wales (Gill, 1940*a*), and a similar species occurs in the Lower Devonian of Indo-China (Mansuy, 1916). The fauna described by Mansuy has other similarities with our Victorian one. *Styliolina* occurs there as it does in Victoria (Gill, 1941), and a shell figured on his Pl. V., fig. 10), is very like our *Chonetes robusta* Chapman. Mansuy, in 1919, described further fossils from that part of the world. His *Chonetes ningpoensis* is reminiscent of our *Chonetes cresswelli* Chapman. The spiriferid of Mansuy's Pl. 5, fig. 6, is very like an undescribed species from Lilydale.

From wide areas of the world and from different stratigraphical horizons, writers have claimed to have found *Calymene blumenbachi* Brongniart. Shirley (1933, p. 62) considers that most of these determinations should be looked upon with suspicion. It appears that in this group a high mutation rate obtained, and numerous closely related forms resulted. Shirley (1936) has described some of the forms closely related to *C. blumenbachi*, and in the present paper it has been shown that *Calymene killarensis*, sp. nov., belongs to this gens. The separation of this series of related forms into distinct species will greatly assist stratigraphical as well as palaeontological studies. A similar review is needed with such brachiopods as *Atrypa reticularis* and *Leptaena rhomboidalis*.

Fossil Localities.

The location of the fossil localities is shown in fig. 2. The numbers are continued from those given previously (Gill, 1940*b* and 1942).

32. "Killara Quarry" is a disused quarry in quartzitic sandstones (with a few interbedded shales) at the end of a disused road. *Anoplia australis* has been collected from there, and as this brachiopod is known only from beds of Yeringian age, the Killara Quarry beds are regarded as Yeringian.

33. "Syme's Homestead".—The first reference to this locality is in Gill, 1939. The fossils were obtained from an old water race near the Wandin Yallock Creek in front of the homestead of the Killara estate. The matrix is a fawn mudstone which has yielded a very rich Yeringian fauna.

34. " Syme's Tunnel ".—This locality is a tunnel which was mined for the purpose of storing apples in the days before cold storage. The rocks are bluish-grey shales which are weathered often to a brownish colour near the surface. As far as can be ascertained, this locality is that which the early Geological Survey records refer to as " Junction of Woori Yallock and Yarra ".

35. " Syme's Quarry " is just below the manager's house on the Killara estate, and was opened up in 1936 to provide stone for private roads on the estate. It consists of the same kind of rock as seen at locality 34 and is on approximately the same strike.

36. " Warburton Highway, Killara " was mentioned in Gill, 1941, p. 152. The locality is a road cutting where whitish mudstones, sometimes coloured red with iron oxide, outcrop. *Styliolina* is abundant.

37. " Seville Limestone " is a disused quarry on the south side of the Warburton highway on the east side of Seville. Except where the rock is weathered the fossils are very difficult to extract, as the " limestone " contains about 60 per cent. silica. Chapman (1908) has recorded fossils from this locality.

38. " Seville cutting " is a long cutting on the Warburton highway immediately west of locality 37. Shales and sandstones outcrop with occasional fossiliferous bands. West of this point to where the bedrock disappears under the igneous rocks of Mt. Dandenong, the outcrops appear to be unfossiliferous.

39. " North of Ruddock's " is a low road cutting north of locality 20. The matrix and fauna are the same as at localities 20 and 21.

Bb20 is a Geological Survey locality so marked on Quarter Sheet 4 SW, where a note refers to the presence of " *Calymene* ". Harris and Thomas (1937, p. 77) refer to the presence at Bb20 of *Monograpti* comparable with forms found in the Melbournian beds.

Acknowledgments.

For access to materials and many other courtesies I am indebted to Professor H. S. Summers of the Geology Department, University of Melbourne, Mr. D. J. Mahony, M.Sc., and Mr. R. A. Keble, F.G.S., Director and Palaeontologist respectively of the National Museum, and Mr. W. Baragwanath of the Geological Survey of Victoria. The photographs are the work of Mr. L. A. Baillôt, of the Melbourne Technical College.

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Description of Plate.

PLATE VII.

FIGS 1, 2, 6.—*Calymene bowiei* sp. nov. 1 and 2 internal cast and external mould respectively, × 1½ approx. Fig. 6 is part of the glabella in fig. 1 enlarged to show nature of ornament as seen on internal cast.

FIGS. 3, 4, 8.—*Calymene killarensis* sp. nov. Figs. 3 and 4 are the internal cast and external mould respectively of a pygidium believed to belong to this species. Fig. 8 is the holotype cranidium × 2.

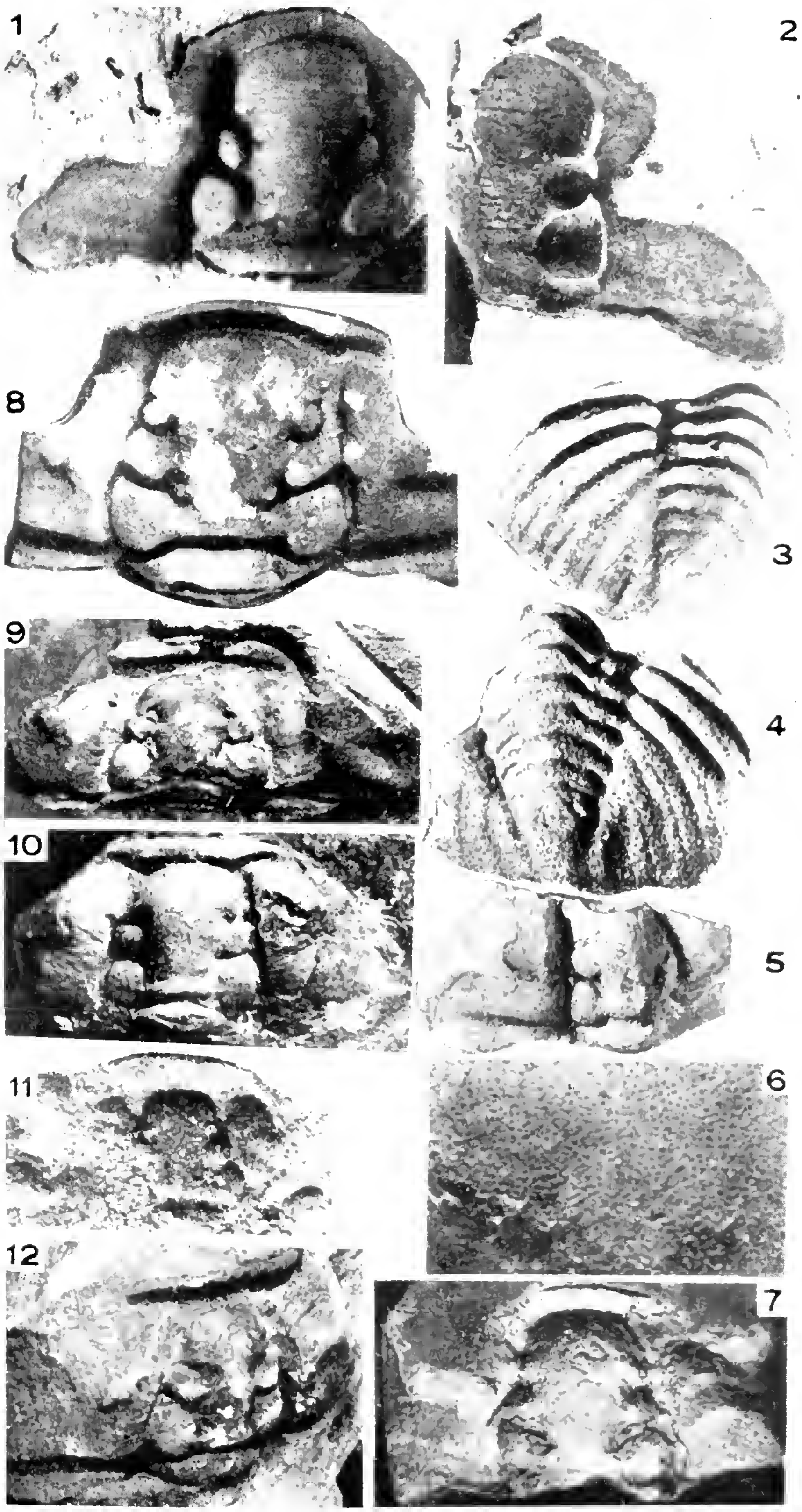
FIGS. 5, 10.—*Gravicalymene angustior* (Chapman). Fig. 5 is the hypotype showing position of the eye and the nature of the suture between the free and fixed cheeks. Fig. 10 is a compressed cephalon referable to this species from Cooper's Cr., Gippsland.

FIG. 12.—*Gravicalymene hetera* sp. nov. Holotype, × 2.

FIG. 9.—*Gravicalymene kilmorensis* sp. nov. Holotype, × 2.

FIG. 7.—*Gravicalymene* cf. *kilmorensis* sp. nov. Specimen from Moonee Ponds Creek × 2.

FIG. 11.—*Flexicalymene* sp. × 2.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[Proc. Roy. Soc. Victoria, 56 (N.S.), Pt. II., 1945.]

Art. XII.—*Recent Foraminifera from Barwon Heads, Victoria.*

By W. J. PARR, F.R.M.S.

[Read 9th December, 1943; issued separately 30th June, 1945.]

Introduction.

Up to the present, only one paper, the well-known one by Mr. Frederick Chapman in the Journal of the Quekett Microscopical Club for 1907, has been published giving a general account of the foraminifera found on the coast of Victoria. While Mr. Chapman's work has been supplemented by descriptions given of a number of species by the present writer, either alone or in

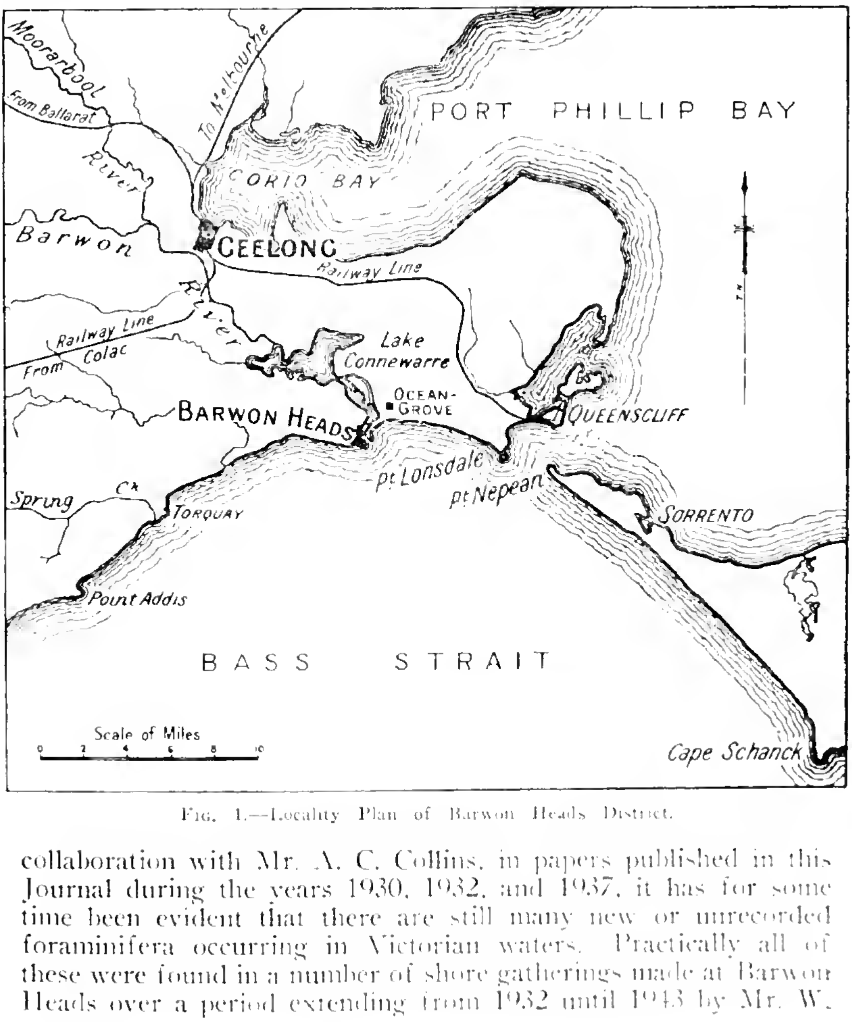

Fig. 1.—Locality Plan of Barwon Heads District.

collaboration with Mr. A. C. Collins, in papers published in this Journal during the years 1930, 1932, and 1937, it has for some time been evident that there are still many new or unrecorded foraminifera occurring in Victorian waters. Practically all of these were found in a number of shore gatherings made at Barwon Heads over a period extending from 1932 until 1943 by Mr. W.

Baragwanath, the Director of the Geological Survey of Victoria, and his daughter, Miss Betty Baragwanath, and kindly made available to me. Apart from the occurrence in the gatherings of practically all of the previously recorded species from Victoria, they provide so much new information on our coastal foraminifera that the following notes have been prepared.

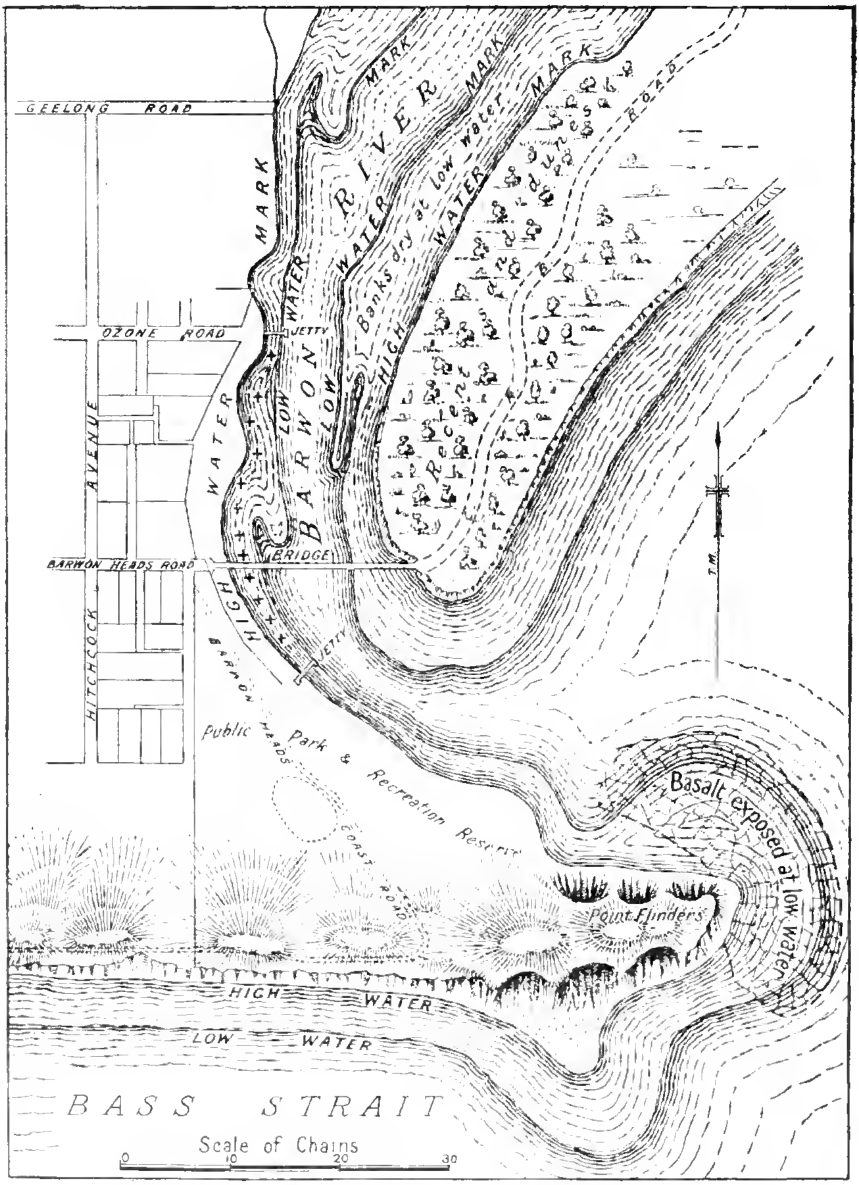

FIG. 2.—Sketch Map of Barwon Heads, showing area from which collections were made indicated thus +.

The township of Barwon Heads is situated on the west side of the mouth of the Barwon River, about six miles west of the entrance to Port Phillip Bay. Between the township and the shores of Bass Strait is the mass of dune limestone, resting on Older Basalt, known as Mt. Colite, which rises conspicuously above the sand dunes which extend for many miles on either side along the coast.

Inland, the Barwon River widens to form Lake Connewarre, on the northern shores and part of the floor of which are deposits of fossiliferous marls of Middle Miocene age. These deposits extend seawards and outcrop on the sea floor at Ocean Grove, a little north-east of the mouth of the Barwon River.

The Barwon River is subject to tidal influence up to a point above the head of Lake Connewarre and the material collected by Mr. Baragwanath has been deposited by the tide on the sandy beach which forms the west bank of the river over a distance of from 20 to 30 chains inland from its mouth.

As might be expected with material collected over so many years and under varying conditions of weather and tide, there is some difference in the number and variety of the foraminifera present in the various gatherings. While the decision to describe the foraminifera was made so late that those from each gathering were not kept separate with a record of the conditions prevailing at the time of collection, it can be stated that, with the following exceptions, the species in each gathering, while varying in abundance, were the usual forms occurring on a sandy bottom in shallow water on the Victorian coast. On one occasion, specimens of *Tretomphalus*, which had clearly drifted in from the open sea, occurred in great numbers, while, on another, numerous examples of a new species of *Webbinella*, an adherent genus, which was not found in any other gathering, were met with. Two or three gatherings were noteworthy for the occurrence of many exceptionally fine specimens of the rare genus *Delosina*, which has since found to be widely distributed in Bass Strait.

A source of difficulty in dealing with the foraminifera has been the presence in the gatherings of fossil species derived from the Tertiary deposits to which reference has been made. These fossil foraminifera are usually so perfectly preserved that their appearance does not differ from that of Recent specimens and they can accordingly only be distinguished by comparison with those occurring in the local Tertiary deposits. After excluding

all fossil and doubtful species, the number of forms recognized as of Recent origin is 142, including 14 which are described as new. To avoid the necessity of giving the synonmy of every species, references to literature are given only when the species has not been previously sufficiently dealt with in publications which are readily available. With these exceptions, the references will be found in one of the following publications :—

Brady, H. B., 1884.—Report on the foraminifera dredged by H.M.S. "Challenger" during the years 1873-1876.—Rep. Voy. *Challenger*, Zoology, vol. 9.

Chapman, F., 1907.—Recent Foraminifera of Victoria: Some Littoral Gatherings. *Journ. Quekett Micr. Club*, ser. 2, vol. 10, pp. 117-146, pls. 9, 10.

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Parr, W. J., and Collins, A. C., 1937.—Notes on Australian and New Zealand Foraminifera. No. 3. Some Species of the Family Polymorphinidae. *Proc. Roy. Soc. Vic.*, n.s. 50 (1), pp. 190-211, pls. 12-15.

It may be noted here that I now believe that the species recorded in my 1932 papers as being from "Williamstown. Silty mud. (Collected many years ago by the late J. Gabriel)" were not of Recent origin, but were from fine washings, of Middle Miocene age, from one of the bores put down in the Williamstown district in search of brown coal. The specimens of *Discorbis margaritifer* recorded at the same time from shore sand, Point Lonsdale, are also now regarded as being from the Middle Miocene deposits in the vicinity of Ocean Grove. Examples of this species occur commonly in the Barwon Heads shore gatherings, where there can be no doubt of their fossil origin.

To Mr. and Miss Baragwanath, I desire to express my sincere thanks for collecting and making the material available for examination. The assistance of Mr. Arthur Kennedy, of the Mines Department, who made the drawings illustrating the paper is also gratefully acknowledged. I am also indebted to Dr. M. F. Glaessner for his advice on the identification of several of the species.

The types and other specimens are in the writer's collection, and will later be deposited in the National Museum, Melbourne.

Systematic List of Species.

Family AMMODISCIDAE.

1. AMMODISCUS MESTAYERI Cushman (Pl. VIII., figs. 1, 2).

A. mestayeri Cushman, 1919, Proc. U.S. Nat. Mus., 56, p. 597, pl. 74, figs. 1, 2.

This species is represented by ten small examples. It was described from off the Poor Knights Islands, off the east coast of New Zealand, and is stated by Cushman to be distinguished by its few coils and protuberant proloculus.

Family SACCAMMINIDAE.

2. PROTEONINA SPICULIFERA Parr (Refs., Parr, 1932, p. 218).

Two specimens similar to those previously figured by the writer from Point Lonsdale, Victoria. The form and wall structure of the test of this species suggest that it may be merely the detached chambers of *Reophax distans*, var. *pseudodistans*, which, like the preceding species, was described by Cushman from off the Poor Knights Islands. No specimens showing an opening at both ends or consisting of more than one chamber have, however, been found and, in the absence of these, the reference to *Proteonina* is retained.

3. WEBBINELLA BASSENSIS, sp. nov. (Pl. VIII., figs. 3*a-c*).

Test adherent, plano-convex, circular in outline, usually with a slight rim around the base; chamber single, undivided, consisting of a hemisphere of chitin which supports the weakly-cemented wall of very fine particles of quartz; dorsally the wall is thin, but it thickens towards the base, where in addition to forming the marginal flange it extends underneath for a short distance to cover part of the chitinous floor; no general aperture; colour very pale fawn. Diameter, 0·5 mm.

There are over 80 specimens, all of which are detached from the object to which they were adherent during life. The present occurrence appears to be unique, as the genus usually occurs in small numbers in comparatively deep water attached to stones and shell fragments. The appearance of the Barwon Heads specimens suggests that they were adherent to marine algae. Usually the chitinous lining is preserved and the protoplasmic body has in many cases collected into a brown, rounded mass on the transparent floor of the test.

W. bassensis does not closely resemble any previously described species of *Webbinella*. For assistance in its identification, I am indebted to Mr. Edward Milton, F.R.M.S., of Torquay, England, who has also kindly forwarded examples of an undescribed English Recent species of *Webbinella* for comparison.

Family LITUOLIDAE.

4. Haplophragmoides canariensis (d'Orbigny) (Refs., Cushman, 1920, p. 38).

There are seven examples of the normal form of this species.

Family TEXTULARIIDAE.

5. Textularia sagittula Defrance (Refs., Brady, 1884, p. 361).

Four typical specimens.

6. Textularia conica d'Orbigny (Refs., Cushman, 1922, p. 22).

A typical example.

7. Textularia pseudogramen Chapman and Parr.

T. gramen Brady (*non* d'Orbigny). 1884, p. 365, pl. 43, figs. 9, 10. Cushman, 1924, Carnegie Inst. Washington Publ. No. 342, p. 15, pl. i., figs. 7, 8.

T. pseudogramen Chapman and Parr, 1937, Aust. Antarctic Expedn., 1911-14 Sci. Repts., Ser. C, vol. I., pt. 2, p 153.

Several examples. This species is common in Bass Strait. As a holotype was not designated when it was described, I now select the original of fig. 9 of Plate 43 of the "Challenger" Report as the type specimen. This was from "Challenger" Stn. 162, off East Moncoeur Island, Bass Strait, 38-40 fms.

Family TROCHAMMINIDAE.

8. Trochammina inflata (Montagu) (Pl. VIII., figs. 4*a*, *b*). (Refs., Brady, 1884, p. 338.)

Many typical specimens. *T. inflata* is one of the group of foraminifera which will tolerate brackish water, and on the Victorian coast it appears to be most at home under these conditions, as it is common at the mouth of Kororoit Creek, near Williamstown, and at the mouth of the Barwon River, but is rare elsewhere.

Family VALVULINIDAE.

9. Clavulina multicamerata Chapman (Refs., Parr, 1932, p. 4).

One specimen. This species is usually more common in Victorian shore sands.

10. EGGERELLA sp. (Pl. VIII., fig. 5).

The only specimen found is probably a new species, but more material is required to determine this. The characters of the specimen, which has a length of 0·35 mm., are shown by the figure. The test, except for the final chamber which is white, is warm brown in colour.

Family VERNEUILINIDAE.

11. GAUDRYINA (PSEUDOGAUDRYINA) HASTATA Parr.

G. hastata Parr, 1932, p. 219, pl. 22, figs. 40 *a*, *b*.

G. (*P.*) *hastata*: Cushman, 1937, Cushman Lab. Spl. Publ. No. 7, p. 95, pl. 14, figs. 7, 8.

Several worn examples.

Family OPHTHALMIDIIDAE.

12. PLANISPIRINA (?) BUCCULENTA (Brady) (Pl. XII., figs. 1*a*, *b*).

Miliolina bucculenta Brady, 1884, p. 170, pl. 114, figs. 3 *a*, *b*.

Planispirina bucculenta: Schlumberger, 1892, Mém. Soc. Zool. France, 5, p. 208, text-figs. 2-4, pl. 8, figs. 6, 7.

There are several examples which, in external characters, are close to Schlumberger's figs. 6 and 7, as well as a number of smaller, irregular, biloculine specimens. This species, which was described from deep water in the North Atlantic, has, at different times, been referred to "*Miliolina*," *Planispirina*, and *Triloculina*, but Schlumberger's figures of sectioned specimens show that the internal structure is not the same as that of any of these genera. Wiesner (1931, Deutsche Südpolar Expedn. 1901-1903. XX. Zool., p. 107, pl. 15, fig. 178) has figured what appears to be this species under the name of *Miliolinella subrotunda* (Montagu), var. *trigonina* Wiesner. The genotype of *Miliolinella*, a genus described by Wiesner in the same work, is *Vermiculum subrotundum* Montagu, the internal structure of which is not fully known, but the megalospheric form, as figured by Sidebottom (1904, Mem. Proc. Manchester Lit. Phil. Soc., vol. 48, No. 5, p. 8, text-fig. 2) from the Eastern Mediterranean, shows a resemblance to the stages following the central disc of the microspheric form of *P.? bucculenta* as figured by Schlumberger. Until the growth stages of the microspheric form of *M. subrotunda* are known, the position of *Miliolinella* is uncertain and I have accordingly referred Brady's species doubtfully to *Planispirina* to which the information available suggests that it is most closely related.

13. NUBECULARIA LUCIFUGA Defrance (Refs., Brady, 1884, p. 134).

Several small examples.

Family MILIOLIDAE.

14. QUINQUELOCULINA DILATATA d'Orbigny (Refs., Cushman, 1929, p. 26).

There are several examples of this West Indian species.

15. QUINQUELOCULINA LAMARCKIANA d'Orbigny (Refs., Cushman, 1929, p. 26).

In his notes on this West Indian species, Cushman states that, in the West Indies, there are two forms which may possibly be distinct. Both have a smooth surface, but in one the peripheral angle is acute and the surface smooth and polished, while in the other the peripheral angle is usually more blunt and the surface dull. The Barwon Heads specimens are similar to the second form. This is common on the Victorian coast.

16. QUINQUELOCULINA SUBPOLYGONA, sp. nov. (Pl. XII., figs. 2*a-c*).

Test about $1\frac{1}{2}$ times as long as broad; chambers distinct; sutures slightly depressed; each chamber polygonal in cross-section, the periphery concave, usually with a projecting, sometimes undulate, carina at either angle; apertural end extended into a short neck, aperture more or less quadrate, with an everted lip and a single bifid tooth; surface dull.

Length 1·0 mm., breadth, 0·6 mm., thickness, 0·4 mm.

This is the commonest species of the genus on the south coast of Australia. It has been confused with *Q. polygona* d'Orbigny, from the West Indies, but has a shorter, more strongly carinate test than that species and is also less regularly built. Another species which resembles *Q. subpolygona* is *Q. sulcata* d'Orbigny, as figured by Cushman (1932, U.S. Nat. Mus., Bull. 161, p. 28, pl. 7, figs. 5-8) from off Fiji. This is proportionately much longer and the apertural end is extended to form a long neck.

17. QUINQUELOCULINA BARAGWANATHI, sp. nov. (Pl. VIII., figs. 6*a-c*; Pl. XII., fig. 3).

Test a little longer than broad, of rather irregular form; periphery subacute; chambers distinct, only moderately inflated; sutures depressed; surface matte, frequently ornamented by short, obliquely curved costae (1 or 2 to a chamber) extending inward from the peripheral angle and sloping toward the apertural end of the chamber; aperture semi-circular, with an everted lip and a flat, semi-circular tooth which is placed in front of the aperture.

Length 0·6 mm., breadth, 0·4 mm., thickness, 0·25 mm.

This is also a common species on the south coast of Australia, and I have specimens from shallow water, near Noumea, New Caledonia. Chapman's record (1907, p. 124) of "*Miliolina*" *undosa* (Karrer) from Torquay, Victoria, probably refers to the same form, but the Recent records of Karrer's species usually relate to a form with a produced apertural neck and a plate-like, sometimes bifid, tooth in the aperture.

18. Quinqueloculina costata d'Orbigny (Refs., Parr, 1932, p. 8).

Examples are common.

19. Spiroloculina antillarum d'Orbigny (Refs., Parr, 1932, p. 9).

One specimen. The Southern Australian examples of this species attain a greater development than those from the West Indies.

20. Spiroloculina milletti Wiesner.

S. nitida Brady (*non* d'Orbigny), 1884, p. 149, pl. 9, figs. 9, 10. Millett, 1898, J. R. M. S., p. 265, pl. 5, figs. 9-13.

S. milletti Wiesner, 1912, Archiv f. Protistenkunde, 25, p. 207. Cushman, 1917, U.S. Nat. Mus., Bull. 71, Pt. 6, p. 33, pl. 5, fig. 4. Wiesner, 1923, Die Miliolideen der östlichen Adria, p. 30, pl. 4, figs. 7, 8.

Fine specimens similar to those figured by Brady are frequent. They are more regularly formed than those figured by Millett from the Malay Archipelago.

21. Spiroloculina limbata d'Orbigny (Refs., Cushman, 1929, p. 44).

Many large specimens.

22. Sigmoilina australis (Parr).

Quinqueloculina australis Parr, 1932, p. 7, pl. 1, figs. 8*a-c*.

This species was described by the writer from 7 miles E. of Cape Pillar, Tasmania, 100fms., and recorded also from shore sand, Point Lonsdale, Victoria, and elsewhere. I am indebted to Mr. Arthur Earland, F.R.M.S., for drawing my attention to the fact that it should be referred to *Sigmoilina*.

23. Triloculina trigonula (Lamarck) (Refs., Cushman, 1929, p. 56).

Examples are common. They are of the large, strongly inflated form which occurs so frequently on the coasts of Victoria and South Australia.

24. TRILOCULINA STRIATOTRIGONULA Parker and Jones.

T. striatotrigonula Parker and Jones, 1865, Phil. Trans. Roy. Soc., 155, p. 438 (*nomen nudum*).

Miliolina insignis Brady, 1884, pl. 4, fig. 10 (*non* fig. 8).
T. insignis Parr, 1932, p. 11, pl. 1, fig. 19.

T. striatotrigonula: Parr, 1941, Mining and Geol. Journ., 2 (5), p. 305.

Small specimens. The reasons for the use of this name instead of *T. insignis* (Brady) are given in the last reference quoted.

25. TRILOCULINA TERQUEMIANA (Brady) (Ref., Brady, 1884, p. 166).

There is one example of this striate form of *T. tricarinata.*

26. TRILOCULINA OBLONGA (Montagu) (Refs., Parr, 1932, p. 10).

Examples are rather common. In addition to the narrow form figured by Williamson, there are some broader specimens and two of the biloculine type I have figured from Point Lonsdale, Victoria.

27. TRILOCULINA CIRCULARIS Bornemann, (Refs., Cushman, 1929, p. 58).

Typical specimens are very common.

28. TRILOCULINA CIRCULARIS Bornemann, var. *sublineata* (Brady).

(Refs., Brady, 1884, p. 169.)

Brady described this form from off the Admiralty Islands, on the north coast of New Guinea, 15-25 fms. As figured by him, it has no apertural tooth or plate, but the Victorian specimens have a fairly large, flat, semi-circular tooth in front of the aperture. There are also more compressed and the chambers are not so inflated. Possibly they represent a new species.

29. TRILOCULINA LABIOSA d'Orbigny (Refs., Parr, 1932, p. 220).

Common.

30. TRILOCULINA LABIOSA d'Orbigny, var. *schauinslandi* (Rhumbler).

(Refs., Parr, 1932, p. 220.)

Examples are very common.

31. TRILOCULINA BASSENSIS, sp. nov. (Pl. VIII., figs 7 *a-c*).

Test longer than broad, triloculine, typically with a truncate periphery which in the final chamber is frequently keeled on each edge; chambers distinct; sutures slightly depressed; surface covered with very short, delicate ridges which give a matte effect; aperture subquadrate, longer than wide, with an everted lip and an elongate tooth which is thicker at the inner end.

Length, 0·75 mm., breadth, 0·6 mm., thickness, 0·37 mm.

In many respects, this species resembles *Quinqueloculina subpolygona*, but is triloculine and smaller than the latter. It may also be compared with *Triloculina irregularis* (d'Orbigny), as figured by Cushman (1932, U.S. Nat. Mus., Bull. 161, Pt. 1, p. 54, pl. 12, figs. 2 *a-c*) from off Fiji, 40-50 fms. In this species, the test in transverse section is almost rectangular, but in *T. bassensis* it is roughly triangular, because, unlike the Fijian species, the outer truncate margin of the penultimate chamber is in a plane oblique to that of the final chamber.

32. Pyrgo denticulata (Brady) (Refs., Cushman, 1929, p. 69).

Several specimens.

33. Nevillina coronata (Millett) (Pl. VIII., figs. 8 *a, b*).

Biloculina coronata Millett, 1898, J.R.M.S., p. 263, pl. 6, figs. 6*a-c*.

Nevillina coronata: Sidebottom, 1905. Mem. Proc. Manchester Lit Phil. Soc., 49 (11), pp. 1-4, pl.

There are eight examples of what appears to be the biloculine or *Pyrgo* stage of this species. They attain a length of 0·9 mm. and closely resemble Millett's figures and Sidebottom's figures 5 and 6. I have similar specimens from off Masthead Island, in the Capricorn Group, off the coast of Queensland, 20 fms. The adult stage, in which the test is unilocular, has not been met with and has apparently been recorded only by Sidebottom, whose specimens were from off the Andaman Islands, 16 fms., and Sulu roadstead, 12 fms.

Family SORITIDAE.

34. Peneroplis planatus (Fichtel and Moll).

P. planatus: Cushman, 1933, U.S. Nat. Mus., Bull. 161, Pt. 2, p. 61, pl. 19, figs. 1-3 (gives refs.).

P. pertusus Parr (*non Nautilus pertusus* Forskal), 1943, Malac Soc. Sth. Aust. Publ. No. 3, p. 22.

Three worn examples. This was previously incorrectly recorded from Barwon Heads by the writer as *P. pertusus*.

Family SPIRILLINIDAE.

35. Spirillina vivipara Ehrenberg (Refs., Cushman, 1931, p. 3).

Two specimens.

36. Spirillina inaequalis Brady (Refs., Brady, 1884, p. 631).

There are many examples of this well-known Indo-Pacific form.

37. Spirillina denticulogranulata Chapman (Refs., Chapman, 1907, p. 133).

This species was described from shore sand, Torquay, Victoria, and is here represented by seven examples. It is probably the same as Brady's *S. limbata*, var. *denticulata*, from off East Moncoeur Island, Bass Strait, 38 fms. Brady has figured only one side of his specimen and, in the writer's opinion, based on the examination of many specimens of *Spirillina* from Bass Strait, the figure represents the dorsal aspect of an asymmetrical form identical with Chapman's species.

38. Spirillina denticulogranulata Chapman, var. *pulchra*, var. nov. (Pl. VIII., figs. 9 *a-c*; Pl. IX., figs. 1 *a-c*).

Variety differing from the typical form of the species in the more numerous whorls and greater number of more delicate tooth-like processes on the dorsal side. Diameter, 0·45 mm.

This form is represented by several specimens. A typical example and what is probably a weakly developed specimen of the same variety are figured. It is intermediate between *S. denticulogranulata* and an undescribed species occurring in the Middle Miocene at Muddy Creek, Victoria, in which the tooth-like processes are absent.

39. Spirillina runiana Heron-Allen and Earland (Pl. IX., figs. 2 *a, b*, 3).

Spirillina vivipara Ehrenberg, var. *runiana* Heron-Allen and Earland, 1930, J.R.M.S., p. 179, pl. 4, figs. 51-53.

Four specimens. This form, which appears to be specifically distinct from *S. vivipara*, was described from off Plymouth, England, from a depth of about 30 fms.

Family NODOSARIIDAE.

40. Lenticulina sp.

Several weak specimens of the *L. gibba* group.

41. Vaginulina vertebralis Parr (Refs., Parr, 1932, p. 221).

Three specimens similar to that described by the writer from shore sand, Torquay, Victoria.

42. Vaginulina bassensis, sp. nov. (Pl. XII., figs. 4 *a, b*).

Test elongate, tapering, somewhat lobulate on the ventral side, compressed in the early stages, later becoming almost circular in transverse section; chambers distinct, increasing in height comparatively quickly, sometimes showing traces of coiling in the

early stages but usually added obliquely at an angle of about 45 deg., or more, with the amount of inflation increasing gradually; sutures distinct, later ones depressed; wall smooth, translucent; aperture eccentric, on the dorsal side, radiate. Length up to 1·5 mm.

There are numerous specimens. This is a puzzling species in several respects. It is not sufficiently compressed to be a typical *Vaginulina* but is nearer this genus than any other. The smaller, less developed specimens resemble some of the open-coiled species of the "*Cristellaria*" *crepidula* group, while a few of the larger examples would be referred to *Dentalina inornata* if found alone. The large series of specimens shows, however, that only one species is present.

43. Dentalina inornata d'Orbigny.

> *D. inornata* d'Orbigny, 1846, For. Foss. Vienne, p. 44, pl. 1, figs. 50, 51. Chapman and Parr, 1937, Aust. Ant. Exped. 1911-14. Sci. Repts. [C.], I. (2), p. 60.

One specimen. This species is better known as *D. communis* d'Orbigny. The reasons for the disuse of this name are given in the reference by Chapman and Parr, quoted above.

44. Dentalina mutsui Hada (Pl. XII., fig. 5).

> *D. mutsui* Hada, 1931, Sci. Repts Tohuku Imp. Univ., Ser. 4, Biology, 6 (1), p 97, text-fig. 50.

I have referred to this species, which was described from Mutsu Bay, Japan, 15-25 fms., a form of *Dentalina* which is very common at Barwon Heads. Except that they attain a length of 2 mm. as against 3·65 mm. in the Japanese examples, the specimens agree with Hada's description and figure.

45. Dentalina guttifera d'Orbigny.

> *D. guttifera* d'Orbigny, 1846, Foram. Foss. Vienne, p. 49, pl. 2, figs. 11-13.
>
> *Nodosaria pyrula* Brady (*non* d'Orbigny), 1884, p. 497, pl. 62, figs. 10-12 (and later authors).

One broken specimen.

46. Nodosaria scalaris (Batsch) (Refs., Brady, 1884, p. 510).

Several examples.

47. Frondicularia compta Brady, var. *villosa* Heron-Allen and Earland (Pl. IX., fig. 4).

> *F. archiaciana* Brady (*non* d'Orbigny), 1884, p. 520, pl. 114, fig. 12.
>
> *F. compta* Brady, var. *villosa* Heron-Allen and Earland, 1924, J.R.M.S., p. 157, pl. 10, figs. 54-55.

Two specimens. This appears to be the only Recent record of this form other than those of Brady and of Heron-Allen and Earland from off Raine Island, 155 fms. The last-named authors also had it from the Miocene of Batesford, Victoria.

48. Lagena laevis (Montagu).

Vermiculum laeve Montagu, 1803, Testacea Britannica, p. 524.

Lagena vulgaris Williamson, 1858, Recent Foram. Gt. Britain, p. 3, pl. 1, figs. 5, 5*a*.

The specimens are not typical, resembling fig. 14 of Pl. 56 of the " Challenger " Report.

49. Lagena perlucida (Montagu) (Refs., Cushman, 1923, p. 46).

The specimens are finely costate on the basal end.

50. Lagena striata (d'Orbigny) (Refs., Cushman, 1923, p. 54).

Typical specimens of the original globular type.

51. Lagena sulcata (Walker and Jacob) (Refs., Cushman, 1923, p. 57).

Good examples are common.

52. Lagena acuticosta Reuss (Refs., Cushman, 1923, p. 5).

The specimens have more costae (18-20) than in the typical form of this species.

53. Lagena acuticosta Reuss, var. *ramulosa* Chapman (Refs., Parr, 1932, p. 11).

This Southern Australian form of *L. acuticosta* is common in most Victorian shore gatherings.

54. Lagena gracillima (Seguenza) (Refs., Cushman, 1923, p. 23).

The specimens are all spirally twisted, and may be merely a smooth form of *L. distoma-margaritifera.*

55. Lagena distoma-margaritifera Parker and Jones (Refs., Parr, 1932, p. 11).

This beautiful species is common.

56. Lagena distoma-margaritifera, var. *victoriensis,* nov. (Pl. XII., fig. 6).

Test elongate, usually spirally twisted, fusiform with the aboral end pointed and the apertural end extended into a long neck which terminates in a phialine lip; surface ornamented with from eight to ten strong costae.

Length up to 1·5 mm.

This form is common in Victorian shore sands. Its shape is similar to that of *L. distoma-margaritifera,* with which it is always associated, and it appears to be only a costate modification of that species. The twisted and costate test distinguish it from *L. distoma* Parker and Jones.

57. Fissurina lucida (Williamson) (Refs., Cushman, 1923, p. 33).

One specimen.

58. Fissurina biancae Seguenza.

F. laevigata Reuss, 1849 (*non Oolina laevigata* d'Orbigny), Denkschr. Akad. Wiss. Wien, 1, p. 366, pl. 46, fig. 1.

F. biancae Seguenza, 1862, Foram. Monot. Marne Miocen. Distretto Messina, p. 57, pl. 1, figs. 48-50.

Lagena biancae: Heron-Allen and Earland, 1932, Discovery Repts., 4, p. 372, pl. 10, figs. 35-39.

One good example. This species has frequently been recorded under the name of *Lagena laevigata* (Reuss) which is preoccupied by an earlier species described by d'Orbigny.

59. Fissurina subquadrata, sp. nov. (Pl. IX., figs. 5 *a*, *b*).

Test much compressed, subquadrate in outline, periphery bluntly carinate; surface with two shallow grooves on each face, parallel to the outside margin and almost meeting at the base; aperture fissurine, extending almost the full width of the test, and opening into a centrally placed entosolenian tube.

Length, 0·4 mm.

Two specimens. *F. quadrata* (Williamson), which this species resembles in many respects, has the apertural end produced into a short neck and the faces of the test are not grooved.

60. Fissurina lacunata (Burrows and Holland).

Lagena castrensis Brady (*non* Schwager), 1884, p. 485, pl. 60, figs. 1, 2

L. lacunata Burrows and Holland, in Jones, 1895, Pal. Soc., vol. for 1895, p. 205, pl. 7, figs. 12 *a*, *b*.

There are many specimens similar to Brady's fig. 1, which was from Bass Strait. In *F. castrensis*, the faces of the test are beaded and not pitted as in *F. lacunata*.

61. Fissurina contusa, sp. nov. (Pl. IX., fig. 6).

Lagena castrensis (?)Brady (*non* Schwager), 1884, pl. 60, fig. 3.

Test compressed, the central body portion nearly circular, apertural end slightly extended, periphery with a moderately sharp keel which surrounds the test and on either side of which is a secondary lateral keel slightly raised above the general surface; wall on the body portion ornamented with a number of small pits which vary in size; aperture fissurine, elongate, and opening into an entosolenian tube which extends about half way down one face of the test and is recurved at its inner end.

Length, 0·35 mm.

This appears to be the same form as that figured by Brady from off Raine Island, Torres Strait, 155 fms., under the name of *Lagena castrensis*.[7] It is common in Bass Strait, and, while usually occurring with *F. lacunata*, differs from this species in its apertural characters and in the weaker pitting of the surface.

62. FISSURINA ORBIGNYANA (Seguenza), variety (Pl. IX., fig. 7).

There are ten examples of a form of *F. orbignyana*, which in front view is pyriform, with the apertural end only slightly extended and the central portion of the test on each side bearing a white, horse-shoe shaped marking, the rounded end of which is directed towards the base of the test.

63. FISSURINA LAGENOIDES (Williamson) (Refs., Cushman, 1923, p. 30).

One fairly typical example.

64. ENTOSOLENIA GLOBOSA (Montagu) (Refs., Cushman, 1923, p. 20).

Numerous specimens. They are nearly all faintly hispid, but one has the surface thickenings developed to such an extent that it could be referred to *E. ampulla-distoma* (Rymer Jones).

65. ENTOSOLENIA SQUAMOSA (Montagu) (Refs., Cushman, 1923, p. 51).

One very typical specimen.

Family POLYMORPHINIDAE.

66. GUTTULINA YABEI Cushman and Ozawa (Refs., Parr and Collins, 1937, p. 192).

Two small examples.

67. GUTTULINA REGINA (Brady, Parker, and Jones) (Refs., Parr and Collins, 1937, p. 193).

Many specimens. A series of abnormal examples of this species from Barwon Heads has been figured by Parr and Collins.

68. GUTTULINA LACTEA (Walker and Jacob) (Refs., Parr and Collins, 1937, p. 195).

Rare, but typical.

69. GUTTULINA SEGUENZANA (Brady) (Refs., Parr and Collins, 1937, p. 196).

Rare. This is already known from the Victorian coast.

70. Globulina gibba d'Orbigny, var. *globosa* (Münster) (Refs., Parr and Collins, 1937, p. 199).

Common. There are many fistulose specimens.

71. Polymorphina howchini Cushman and Ozawa (Refs., Parr and Collins, 1937, p. 202).

Several examples.

72. Sigmomorphina williamsoni (Terquem) (Refs., Parr and Collins, 1937, p. 205).

Two specimens. This has been previously figured by the writer from Hobson's Bay.

73. Sigmoidella elegantissima (Parker and Jones) (Refs., Parr and Collins, 1937, p. 206).

Six small examples.

Family HETEROHELICIDAE.

74. Bolivinella folium (Parker and Jones) (Refs., Parr, 1932, p. 223).

Several worn examples.

Family BULIMINIDAE.

75. Buliminella elegantissima (d'Orbigny) (Refs., Brady, 1884, p. 402).

Two good examples.

76. Buliminoides williamsonianus (Brady) (Refs., Brady, 1884, p. 408).

Three specimens. This species ranges from Torres Strait down the east coast of Australia and westward to South Australian waters. It is most common in shallow water.

77. Bulimina marginata d'Orbigny (Refs., Brady, 1884, p. 405).

Three specimens. The Australian examples are usually proportionately shorter than those from Europe.

78. Virgulina schreibersiana Czjzek.

V. schreibersiana: Cushman, 1937, Cushman Lab. Spl. Publ. No. 9, p. 13, pl. 2, figs. 11-20 (gives refs.).

Several large examples. This species also occurs in Westernport Bay, Victoria.

79. Bolivina compacta Sidebottom (Pl. IX., fig. 8).

B. compacta: Cushman, 1937, Cushman Lab. Spl. Publ. No. 9, p. 135, pl. 17, figs. 22-24 (gives refs.).

Two specimens. Cushman records this species from a number of shallow water dredgings in the tropical Pacific.

80. Bolivina pseudoplicata Heron-Allen and Earland (Pl. IX., fig. 9).

B. pseudoplicata: Cushman, 1937, Cushman Lab. Spl. Publ. No. 9, p. 166, pl. 19, figs. 12-20 (gives refs.).

Typical examples are common.

81. Rectobolivina digitata, sp. nov. (Pl. IX., fig. 10).

Test elongate, compressed, straight or slightly curved, with the margins lobulate, biserial portion with a slight median depression on each of the broad faces, uniserial portion also depressed in the upper part of the centre of each chamber; sutures distinct, often a little depressed; chambers numbering 6 to 8 in the biserial portion, with 5 or 6 in the uniserial portion; wall calcareous, smooth, fairly coarsely perforate except along the median line; aperture elliptical, with a rounded rim. Length, 0·6 mm.; breadth, 0·15 mm.

There are two examples from Barwon Heads and I have a number from the Post-Tertiary of Victorian Mines Department Bore No. 5, Parish of Wannaeue, near Rosebud, 177-187 feet. This species differs from the well-known Indo-Pacific Recent species, *R. bifrons* (Brady), in its more irregular build, greater number of biserial chambers, less compressed uniserial portion, and more coarsely perforated test.

82. Reussella armata (Parr) (Refs., Parr. 1932, p. 224).

Three examples. The only previous record of this species is from shore sand, Hardwicke Bay, South Australia.

83. Chrysalidinella dimorpha (Brady) (Refs., Brady, 1884, p. 388).

One specimen. It is proportionately narrower and more heavily built than are the tropical examples of this species.

84. Uvigerina sp. cf. pigmea d'Orbigny.

There are six specimens of the form I have recorded (1939, Mining Geol. Journ., 1 (4), p. 68, pl., fig. 14) from the Lower Pliocene of Gippsland. It is probably not d'Orbigny's *U. pigmea*, but this cannot at present be determined with certainty.

85. Siphogenerina raphanus (Parker and Jones) (Refs., Parr, 1932, p. 225).

Examples are frequent and typical.

86. Angulogerina angulosa (Williamson).

Uvigerina angulosa Williamson, 1858, Recent Foram. Gt. Britain, p. 67, pl. 5, fig. 140.

There are three specimens similar to examples of the typical British form of this species from Dog's Bay, Ireland.

Family CASSIDULINIDAE.

87. Cassidulina laevigata d'Orbigny (Refs., Brady, 1884, p. 428).

One small specimen.

88. Cassidulina subglobosa Brady (Refs., Cushman, 1922, p. 127).

Three small specimens.

89. Ehrenbergina pacifica Cushman.

E. pacifica Cushman, 1927, Proc. U.S. Nat. Mus., 70, Art. 16, p. 5, pl. 2, figs. 2 *a-c*.

One small example. This species is common off the coast of New South Wales.

Family DELOSINIDAE.

90. Delosina complanata Earland (Pl. X., figs. 1, 2).

Polymorphina complexa Sidebottom, 1907, Mem. Proc. Manchester Lit. Phil. Soc., 51 (9), p. 16, pl. 4, figs. 4, 8, (?) 9. Heron-Allen and Earland, 1916, J.R.M.S., p. 48, pl. 8, figs. 5-7.

Delosina complanata Earland, 1934, Discovery Reports, 10, p. 128.

One of the most interesting occurrences in the shore gatherings from Barwon Heads is that of numerous examples of the genus *Delosina*. The specimens are exceptionally well developed and are very variable in form. Generally, however, the chambers are almost biserially opposed on a plan similar to the chambers in the genus *Sigmomorphina*. The plan of growth is best shown in the large compressed specimens, one of which is represented by fig. 2 of Pl. X. While Earland has described the chambers as at first triserial rapidly becoming biserial and opposed, the chambers in the Victorian examples appear to be biserial from the beginning but in the early stages are separated by a greater angle than the

later chambers, giving a twisted effect to the test when viewed from the base. The Wiesner canals with the needle-stitch-like openings through which they communicate with the exterior of the test are recognisable in all specimens. There are usually a number of pits on the surface of the end of that last-formed chamber, but there is no general aperture. In one specimen sectioned, the first two chambers showed a comparatively large, rounded, terminal opening; This may, however, be due to the resorption of the end of the chamber.

According to Earland, *D. complanata* always occurs in the Mediterranean with *D. complexa* and with about equal rarity. He also records the species from South Cornwall and from off Cape Horn. This gives it a very wide distribution. In addition to the Barwon Heads examples, I have met with the species in a number of dredgings from Bass Strait, and in shore sands from the north coast of Tasmania.

The Victorian specimens are usually half as large again as those figured by Sidebottom from the Eastern Mediterranean, attaining a length of 0·75 mm.

Family ROTALIIDAE.

91. Patellina corrugata Williamson.

P. corrugata Williamson, 1858, Recent Foram, Gt. Britain, p. 46, pl. 3, figs. 86-89. Parr and Collins, 1930, Proc. Roy. Soc. Vic., n.s. 43 (1), p. 90, pl. 4, figs. 1-5.

Two examples.

92. Annulopatellina annularis (Parker and Jones) (Refs., Parr, 1932, p. 225).

Many specimens.

93. Patellinella inconspicua (Brady).

P. inconspicua: Parr and Collins, 1930, Proc. Roy. Soc. Vic., n.s. 43 (1), p. 92, pl. 4, fig. 7 (gives refs.).

Typical examples occur frequently.

94. Discorbis dimidiatus (Jones and Parker) (Refs., Parr, 1932, p. 227).

Common. This is the most abundant species of *Discorbis* on the southern coast of Australia.

95. Discorbis globularis (d'Orbigny) (Refs., Cushman, 1931, p. 22).

One example, more depressed than usual, and with a subcarinate margin to the test.

96. Discorbis globularis (d'Orbigny), var. *anglica* Cushman (Pl. IX., figs. 11 *a-c*).

D. globularis, var. *anglica* Cushman, 1931, p. 23, pl. 4, figs. 10*a-c*.

D. irregularis Parr (*non Discorbina irregularis* Rhumbler), 1943, Malac. Soc. Sth. Aust. Publ. No. 3, p. 16.

Many specimens. I previously recorded this form as *D. irregularis* (Rhumbler), which in most respects is resembles, but the specimens do not have the several apertures found on the peripheral margin of the later chambers in Rhumbler's species from the tropical Pacific.

97. Discorbis australis Parr (Refs., Parr, 1932, p. 227).

This species was described from San Remo, Victoria. It is common at Barwon Heads.

98. Discorbis patelliformis (Brady) (Refs., Brady, 1884, p. 647).

This well-known Indo-Pacific species is represented by a few small examples.

99. Discorbis australensis Heron-Allen and Earland.

Discorbina pileolus Brady (*non Valvulina pileolus* d'Orbigny), 1884, p. 649, pl. 89, figs. 2-4 (and later authors).

Discorbis australensis Heron-Allen and Earland, 1932, Discovery Repts., 4, p. 416. Parr, 1939, Mining and Geol. Journ., 1 (4), p. 68.

This species is well known from the east coast of Australia under the name of *D. pileolus*. At Barwon Heads it occurs frequently.

100. Discorbis opercularis (d'Orbigny) (Refs., Brady, 1884, p. 650).

Rare.

101. Discorbis kennedyi, sp. nov. (Pl. IX., figs. 12 *a, b*, 13, 14 *a, b*).

Test depressed conical, ventral side slightly concave, periphery subacute; chambers not distinct, 4 to 5 in the last-formed whorl, regularly increasing in size, overlapping on the ventral side; spiral suture depressed in the later part of the test, chamber sutures directed backwards and slightly curved on the dorsal side, usually indistinct, almost radial and somewhat depressed on the ventral side; wall irregularly thickened so as to give an arenaceous appearance to the surface, finely perforate, the periphery limbate; aperture ventral, at the base of the last-formed chamber, opening into the umbilical depression; colour white to pale-brown.

Diameter, 0·4 mm.

There are eleven examples of this species, which appears to be a local form, as I have not met it elsewhere on the Australian coast or in material from other parts of the world. The under side of the last-formed chamber is easily broken, as every specimen is incomplete in this respect. The rough surface texture and the usually brownish colour give an appearance like that of some species of *Trochammina*. I have pleasure in associating the name of Mr. Arthur Kennedy, of the Victorian Department of Mines, with this species.

102. Discorbis williamsoni Chapman and Parr (Pl. X., figs. 3 *a, b*).

D. williamsoni Chapman and Parr M.S.: Parr, 1932, p. 226, pl. 21, fig. 25 (gives earlier refs.). Chapman and Parr, 1937, Aust. Antarctic Exped. 1911-14, Sci. Repts. [C.], 1 (2), p. 105, pl. 8, fig. 23.

Many examples.

103. Discorbis pulvinatus (Brady) (Ref., Brady, 1884, p. 650).

Three typical specimens. This species is common in shallow water on the south coast of Australia.

104. Discorbis bertheloti (d'Orbigny) (Refs., Cushman, 1931, p. 16).

Two small specimens.

105. Discorbis rarescens (Brady) (Pl. X., figs. 5 *a-c*) (Ref., Brady, 1884, p. 651).

Three examples. Brady's specimens were from off Raine Island, Torres Strait, 155 fms., and off the Philippines, 95 fms.

106. Discorbis grossepunctatus, sp. nov. (Pl. X., figs. 4 *a-c*).

Test plano-convex, oval, peripheral margin limbate, bluntly keeled; chambers, usually four in the final whorl the last much larger than the others; sutures slightly depressed, distinct, almost radial on the dorsal side, limbate and strongly recurved on the ventral side; wall very coarsely perforate on the dorsal side, smooth and finely perforate ventrally, with a deposit of shell material in the centre of the test; aperture not clearly visible but possibly a very low slit extending from near the periphery along the base of the last-formed chamber to near the centre of the test. The curvature of the sutures on the flat side of the test suggests that this species would be better referred to *Cibicides*.

Greater diameter, 0·65 mm.; lesser diameter, 0·4 mm.

Two specimens. I have other examples from the Middle Miocene of Mines Department bore No. 1, Parish of Yulecart, near Hamilton, 80-85 ft. This is not a typical *Discorbis*, but resembles *D. rarescens* and some of the forms referred by authors to *D. bertheloti*, in which the earlier whorls are visible only on the ventral side. The aperture cannot be determined with certainty, and it is possible that it is absent. A similar difficulty is frequently experienced in detecting the ventral aperture in species of *Discorbinella*.

107. Heronallenia lingulata (Burrows and Holland).

H. lingulata: Chapman, Parr, and Collins, 1934, Journ. Linn. Soc. (London)—Zool., 38, p. 564, pl. 8, figs. 11*a-c* (gives refs.).

Three typical examples.

108. Heronallenia translucens, sp. nov. (Pl. IX., figs. 15, 16).

Test small, suboval in outline, compressed, dorsal side more convex than the ventral which is depressed in the median portion, peripheral margin subacute and slightly keeled; chambers few, arranged in one and a half whorls, with six chambers in the outside whorl; sutures distinct, limbate, flush, recurved on the dorsal side and nearly radial on the ventral; wall smooth, finely perforate, usually translucent; aperture ventral, an elongate opening extending from the umbilical area towards the front of the last-formed chamber. Length, up to 0·35 mm.

This species is represented by two examples and it also occurs in dredgings from Bass Strait. It differs from described species of *Heronallenia* in its well-inflated test, flush dorsal sutures, and the absence of any thickening of the shell wall on the upper surface.

109. Discorbinella biconcava (Jones and Parker).

Discorbina biconcava Jones and Parker, in Carpenter, 1862, Intro. Study Foram., p. 201, text-fig. 32 G. Brady, 1884, p. 653, pl. 91, fig. 2 (*non* 3).

Planulinoides biconcavus: Parr, 1941, Mining and Geol. Journ., 2 (5), p. 305, text-fig. (after Brady).

There are many examples of this typically Southern Australian species. Since erecting the genus *Planulinoides* for its reception, I have recognized the presence in some specimens of the normal ventral discorbine aperture in addition to that on the periphery. *Planulinoides* should therefore be suppressed and the species referred to *Discorbinella*.

110. Discorbinella planoconcava (Chapman, Parr, and Collins) (Pl. XI., figs. 1, 2).

Planulina biconcava (Jones and Parker), var. *planoconcava* Chapman, Parr, and Collins MS., in Parr, 1932, p. 232, pl. 22, figs. 34 *a-c*

Discorbis planoconcava Chapman, Parr, and Collins, 1934, Journ. Linn. Soc. (London)—Zool., 38, p. 561, pl. 11, figs. 40 *a-c*.

There are sixteen examples of this species, which was described from the Middle Miocene of Victoria and also recorded as a Recent form from shore sand, Point Lonsdale, Victoria.

111. DISCORBINELLA DISPARILIS (Heron-Allen and Earland) (Pl. XI., figs. 3 *a-c*) (Refs., Parr, 1932, p. 230).

There are 22 specimens. Like the preceding species, this is a typical *Discorbinella,* with two apertures, one peripheral and the other ventral. It was originally described from off New Zealand, 100 fms., and later recorded by the writer from shore sand, Victoria, and Hardwicke Bay, South Australia.

112. DISCORBINELLA INVOLUTA (Sidebottom).

Discorbina involuta Sidebottom, 1918, J. R. M. S., p. 255, pl. 6, figs. 15-17.

Four specimens. Sidebottom's record was from off the coast of New South Wales, 465 fms. The species is widely distributed on the east coast of Australia and in Bass Strait.

113. VALVULINERIA COLLINSI (Parr).

Discorbis collinsi Parr, 1932, p. 230, pl. 22, figs. 33 *a-c*.

Seven specimens. The original record of this species was from shore sand, Port Fairy, Victoria.

114. TRETOMPHALUS CONCINNUS (Brady) (Pl. XI., figs. 4, 5).

T. concinnus: Cushman, 1934, Contrbns. Cushman Lab. Foram. Research, 10 (4), p. 96, pl. 11, figs. 8, 9; pl. 12, figs. 13-15 (gives Brady's ref.).

Examples were very common in one gathering.

115. TRETOMPHALUS PLANUS Cushman.

T. planus Cushman, 1934. Contrbns. Cushman Lab. Foram. Research, 10 (4), p. 94, pl. 11, figs. 11*a-c;* pl. 12, figs. 18-22.

Like the preceding, this species was very common in one gathering. While the majority of the specimens have the depressed, cushion-like shape represented by Cushman's fig. 11 *b*, many are subglobular because of the deeper, more rounded balloon chamber. The number of *Cymbaloporetta*-like chambers underlying the balloon chamber is usually four, but is sometimes five. Cushman described this species from off Samoa, 7 fms., and he gives other records from the tropical Pacific. The genus *Tretomphalus* is, from published records, typically of tropical habitat, and its occurrence in such numbers at Barwon Heads is therefore unusual. Occasional examples of *T. concinnus* occur in Victorian shore sands and in dredgings from Bass Strait, but this is the only occasion on which I have met with *T. planus* in this area. Mr. Arthur Earland, F.R.M.S. (1902, Journ. Quekett Micr. Club, [2], 8, (51), pp. 309-322) has recorded a remarkable occurrence of *Tretomphalus* at Corny Point, on Hardwicke Bay, Spencer Gulf, South Australia. From his description, it appears that the species he had was *T. concinnus.*

116. EPONIDES CONCENTRICUS (Parker and Jones) (Pl. XI., figs. 6 *a, b*) (Refs., Cushman 1931, p. 43).

Frequent. The characters of this species suggest that it might be referred to *Mississippina* rather than to *Eponides*.

117. STREBLUS BECCARII (Linné) (Refs., Cushman, 1931, p. 58).

Many specimens. They do not attain the development of the species as it occurs in the Adriatic Sea, but are exactly similar to British examples Mr. Arthur Earland has sent me from Tents Muir, Fifeshire, Scotland. The usual number of chambers in the outside whorl is ten.

118. STREBLUS PAUPERATUS Parr.

Rotalia perlucida Parr (*non* Heron-Allen and Earland), 1932, p. 211, pl. 22, figs. 35*a-c*.

Streblus pauperatus Parr, 1941, Mining and Geol. Journ. 2 (5), p. 305.

Two examples. The previous record of this species was from shore sand, Hardwicke Bay, South Australia.

119. NOTOROTALIA CLATHRATA (Brady).

Rotalia clathrata Brady, 1884, p. 709, pl. 107, fig. 8 (*non* 9).

Notorotalia clathrata: Finlay, 1939, Trans. Roy. Soc. N.Z., 68, p. 518 (note under *N. zelandica* Finlay).

Several examples. This is a common Bass Strait species.

120. CANCRIS sp. (Pl. XI., figs. 7 *a-c*).

The figures represent what appears to be a species of *Cancris*. The test is roughly ear-shaped in outline, with a lobulated periphery. The chambers, which are inflated, increase rapidly in size as added and the sutures are well depressed. The greater part of the face of the last-formed chamber is occupied by a clear, apparently imperforate, area. The base of this is extended as a lip under which the aperture opens into the umbilical cavity. While the species is probably new, there are too few specimens available to enable its characters to be fully determined.

121. BAGGINA PHILIPPINENSIS (Cushman).

Cancris philippinensis: Parr, 1939, Mining and Geol. Journ., 1 (4), p. 69, pl., figs. 18*a-c* (gives refs.).

Five small specimens. This species occurs frequently in dredgings off the coast of New South Wales, at depths of about 100 fms., and is common in the Pliocene of Victoria.

122. ANOMALINA NONIONOIDES Parr (Refs., Parr, 1932, p. 231).

There are ten specimens. This species was described by the writer from shore sand, Narrabeen, New South Wales, and also recorded from shore sand, Torquay, Victoria.

123. CIBICIDES LOBATULUS (Walker and Jacob) (Refs., Cushman, 1931, p. 118).

Examples are common. In addition to the usual form of this species, there are many specimens showing a *Dyocibicides* plan of growth and three with the chambers arranged as in *Rectocibicides.* Some English examples of *C. lobatulus* also develop a biserial habit of growth, although I have not seen any with as many biserial chambers as those from Barwon Heads.

124. PLANORBULINA MEDITERRANENSIS d'Orbigny (Refs., Cushman, 1931, p. 129).

There are numerous examples of the very well-developed form so common in Victorian shore sands. This is possibly not the same as d'Orbigny's species.

125. ACERVULINA INHAERENS Schultze (Refs., Cushman, 1931, p. 134).

Several specimens.

126. GYPSINA VESICULARIS (Parker and Jones) (Refs., Cushman, 1931, p. 135).

Six specimens. They are almost hemispherical in shape, and are very neatly built.

127. MINIACINA MINEACEA (Pallas).

Polytrema mineaceum: Heron-Allen and Earland, 1922, Brit. Antarctic ("Terra Nova") Expedn., 1910, Nat. Hist. Rept., Zool., 6 (2), p. 221, pl. 8, figs. 1-31.

Recognizable fragments only. This species is common on the coast of New South Wales.

Family CHILOSTOMELLIDAE.

128. SPHAEROIDINA BULLOIDES d'Orbigny (Refs., Cushman, 1924, p. 36).

Small specimens.

Family ORBULINIDAE.

129. Globigerina bulloides d'Orbigny.

G. bulloides d'Orbigny, 1826, Ann. Sci. Nat., 7, p. 277, No. 1; Modèles Nos. 17, 76. Cushman, 1941, Contrbns. Cushman Lab., 17 (2), p. 38, pl. 10, figs. 1-13.

Frequent, but small.

130. Globigerina inflata d'Orbigny (Refs., Cushman, 1924, p. 12).

Frequent.

131. Globigerinoides ruber (d'Orbigny) (Refs., Cushman, 1924, p. 15).

Seven specimens. Like all other Southern Australian examples of this species I have seen, they are colourless.

132. Orbulina universa d'Orbigny (Refs., Cushman, 1924, p. 28).

Several examples.

133. Globorotalia hirsuta (d'Orbigny) (Refs., Cushman, 1931, p. 99).

This pelagic species is represented by a single example.

124. Globorotalia truncatulinoides (d'Orbigny) (Refs., Cushman, 1931, p. 97).

Typical examples.

Family NONIONIDAE.

135. Nonion depressulus (Walker and Jacob).

N. depressulum: Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 20, pl. 5, figs. 22-25 (gives refs.).

Rare. The specimens are similar to some I have from Bognor, England.

136. Nonion scapha (Fichtel and Moll).

N. scapha: Cushman, 1939, U.S. Geol. Surv. Prof. Paper 191, p. 20, pl. 5, figs. 18-21 (gives refs.).

Four examples of the typical form of this species. The number of chambers in the last-formed coil varies from eleven to twelve.

137. Elphidium sp. cf. simplex Cushman (Pl. XI., fig. 8).

Cf. *E. simplex* Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 62, pl. 17, fig. 10 (gives refs.).

There are several examples of a species of *Elphidium* which may be a temperate water form of *E. simplex*, described by Cushman from off Tonga, in the South Pacific. The retral processes are better defined than in Cushman's figure, and there is no boss in the umbilical region, which is merely granulated.

138. Elphidium sp. aff. articulatum (d'Orbigny) (Pl. XI., figs. 9 *a*, *b*).

Cf. *E. articulatum*: Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 53, pl. 14, figs. 18, 19.

The specimens agree with *E. articulatum* in the shape and number of chambers to a whorl (10), but the test is narrower in apertural view in the earlier portion and the umbilical region is superficially thickened. *E. articulatum* was described from the vicinity of the Falkland Islands.

139. Elphidium advenum (Cushman)

E. advenum (Cushman): Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 60, pl. 16, figs. 31-35 (gives refs.).

Several examples. They resemble fig. 1 of Pl. 110 of the "Challenger" Report.

140. Elphidium argenteum, sp. nov. (Pl. XII. figs. 7 *a*, *b*.).

Test comparatively large, compressed, periphery subacute with a small blunt keel, margin slightly lobulated, sides nearly parallel in front view, umbilical regions moderately depressed with the surface thickened; chambers numerous, 15–17 in the last-formed whorl, slightly inflated; sutures recurved, obscured by the retral processes, which are rod-like and fairly conspicuous, averaging about 12 in number; surface closely and finely beaded, giving a silvery appearance to the test; aperture a series of rounded openings situated a short distance above the base of the apertural face. Diameter, up to 1 mm.; thickness, to 0·35 mm.

This is the commonest species of *Elphidium* in Victorian shore sands. It is apparently the same species as that recorded by Chapman (1907, p. 141) as *Polystomella striatopunctata* (Fichtel and Moll) from a number of Victorian littoral gatherings, but Fichtel and Moll's figures show that their species is an unrelated form. Like most species of *Elphidium*, *E. argenteum* appears to be restricted in its occurrence. *E. advenum*, var. *margaritacea* Cushman, from off Rhode Island, U.S.A., shows some resemblance to it but has fewer chambers and retral processes.

141. Elphidium macellum (Fichtel and Moll).

E. macellum (Fichtel and Moll); Cushman, 1939, U.S. Geol. Surv. Prof. Paper 191, p. 51, pl. 14, figs. 1-3; pl. 15, figs. 9, 10.

Several specimens.

142. Elphidium imperatrix (Brady) (Refs., Brady, 1884, p. 738).

Three immature examples. This species appears to be confined to an area extending along the east coast of Australia from near Sydney to Tasmania.

Explanation of Plates.

Plate VIII.

Figs. 1, 2.—*Ammodiscus mestayeri* Cushman × 40.

Fig. 3.—*Webbinella bassensis*, sp. nov. Holotype. × 40.

Fig. 4.—*Trochammina inflata* (Montagu). × 40.

Fig. 5.—*Eggerella* sp. × 65.

Fig. 6.—*Quinqueloculina baragwanathi*, sp. nov. Holotype. *a*, *b*, opposite sides. × 40; *c*, apertural view. × 65.

Fig. 7.—*Triloculina bassensis*, sp. nov. Holotype. *a*, *b*, opposite sides. × 40; *c*, apertural view. × 65.

Fig. 8.—*Nevillina coronata* (Millett). Biloculine specimen. *a*, front view. × 40; *b*, side view. × 35.

Fig. 9.—*Spirillina denticulogranulata* Chapman, var. *pulchra* nov. *a*, *b*, opposite sides; *c*, peripheral view. × 65.

Plate IX.

Fig. 1.—*Spirillina denticulogranulata* Chapman, var. *pulchra*, nov. Holotype of variety. *a*, *b*, opposite sides. × 55; *c*, peripheral view. × 65.

Fig. 2.—*Spirillina runiana* Heron-Allen and Earland. *a*, dorsal view; *b*, peripheral view. × 65.

Fig. 3.—*Spirillina runiana* Heron-Allen and Earland. Ventral aspect. × 65.

Fig. 4.—*Frondicularia compta* Brady, var *villosa* Heron-Allen and Earland. × 40.

Fig. 5.—*Fissurina subquadrata*, sp. nov. Holotype. *a*, front view; *b*, apertual view. × 65.

Fig. 6.—*Fissurina contusa*, sp. nov. Holotype. Front view. × 65.

Fig. 7.—*Fissurina orbignyana* Seguenza, var. Front view. × 65.

Fig. 8.—*Bolivina compacta* Sidebottom. × 65.

Fig. 9.—*Bolivina pseudoplicata* Heron-Allen and Earland. × 65.

Fig. 10.—*Rectobolivina digitata*, sp. nov. Holotype. × 65.

Fig. 11.—*Discorbis globularis* (d'Orbigny), var *anglica* Cushman. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. × 65.

Fig. 12.—*Discorbis kennedyi*, sp. nov. Holotype. *a*, dorsal view; *b*, peripheral view. × 65.

Fig. 13.—*Discorbis kennedyi*, sp. nov. Ventral view of another example. × 65.

Fig. 14.—*Discorbis kennedyi*, sp. nov. Another example. *a*, ventral view; *b*, peripheral view. × 65.

Fig. 15, 16. *Heronallenia translucens*, sp. nov. Fig. 15. Holotype. Dorsal view. Fig. 16. Ventral view of another example. Both × 65.

Plate X.

Figs. 1, 2.—*Delosina complanata* Earland. Fig. 1, *a*, *b*, opposite sides; *c*, edge view. Fig. 2, *a*, *b*, opposite sides. All × 65.

Fig. 3.—*Discorbis williamsoni* Chapman and Parr, *a*, dorsal view; *b*, ventral view. × 65.

Fig. 4.—*Discorbis grossepunctatus*, sp. nov. Holotype. *a*, dorsal view; *b*, ventral view; *c*, edge view. × 65.

Fig. 5.—*Discorbis rarescens* (Brady), *a*, dorsal view; *b*, ventral view; *c*, edge view. × 65.

Plate XI.

Figs. 1, 2.—*Discorbinella planoconcava* (Chapman, Parr and Collins). Fig. 1, *a*, *b*, dorsal and ventral views. Fig. 2, edge view of another specimen showing peripheral aperture. All × 65.

Fig. 3.—*Discorbinella disparilis* (Heron-Allen and Earland), *a*. dorsal view; *b*. ventral view; *c*. edge view. × 65.

Figs. 4, 5.—*Tretomphalus concinnus* (Brady). Fig. 4, side view. Fig. 5, dorsal view of another specimen. Both × 65.

Fig. 6. *Eponides concentricus* (Parker and Jones). *a*, dorsal view; *b*, ventral view. × 65.

Fig. 7.—*Cancris* sp. *a*, dorsal view; *b*, ventral view. × 40; *c*, edge view. × 65.

Fig. 8.—*Elphidium* sp. cf. *simplex* Cushman. × 65.

Fig. 9.—*Elphidium* sp. aff. *articulatum* (d'Orbigny). *a*, side view; *b*, apertural view. × 65.

Plate XII.

Fig. 1.—*Planispirina* (?) *bucculenta* (Brady). *a*, side view; *b*, apertural view. × 43.

Fig. 2.—*Quinqueloculina subpolygona*, sp. nov. Holotype. *a*, *b*, opposite sides; *c*, apertural view. × 43.

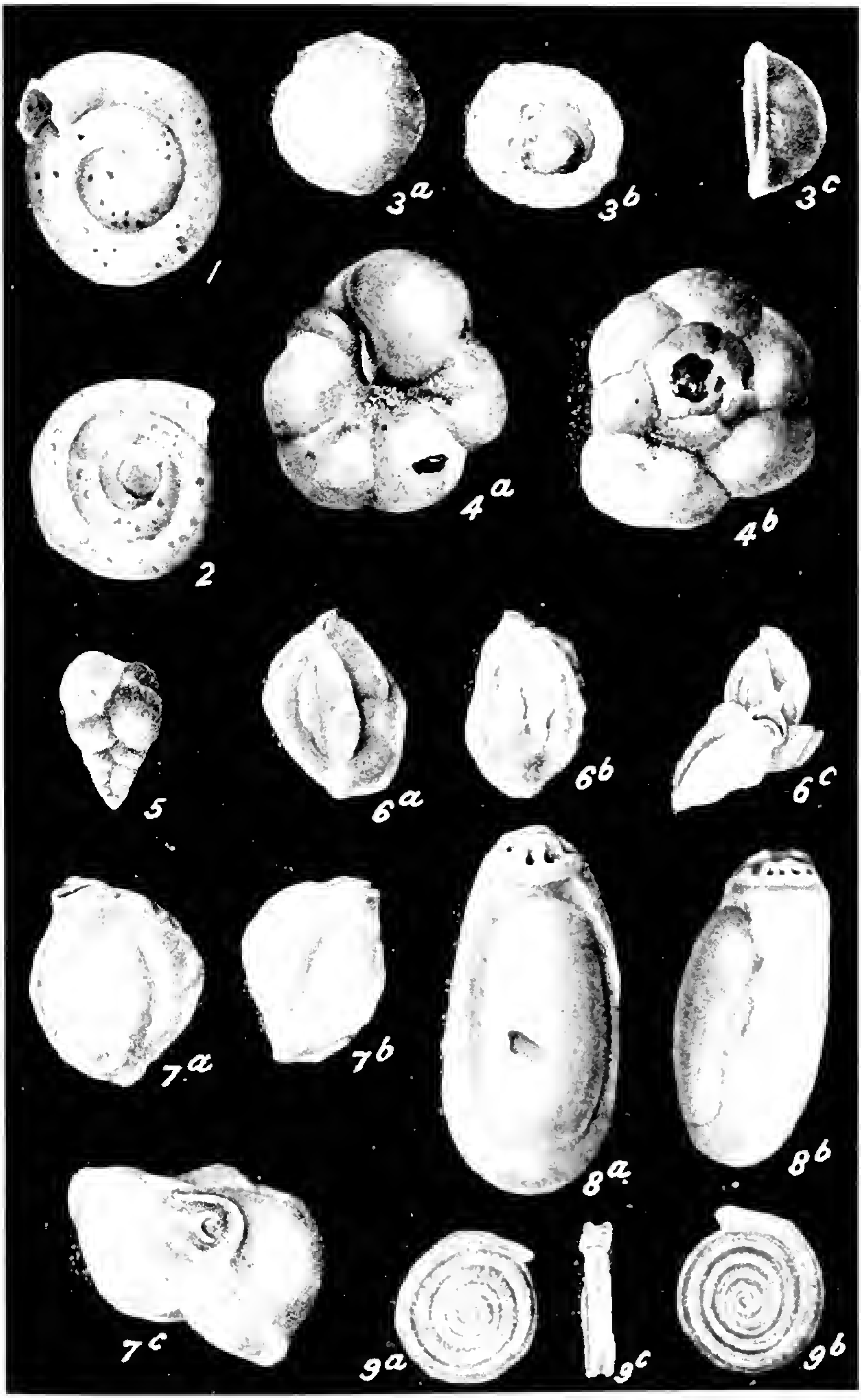
Fig. 3.—*Quinqueloculina baragwanathi*, sp. nov. Front view. × 43.

Fig. 4.—*Vaginulina bassensis*, sp. nov. Holotype. × 43.

Fig. 5.—*Dentalina mutsui* Hada. × 43.

Fig. 6.—*Lagena distoma-margaritifera* Parker and Jones, var. *victoriensis*, nov. Holotype of variety. × 43.

Fig. 7.—*Elphidium argenteum*, sp. nov. Holotype, *a*, side view; *b*, apertural view. × 43.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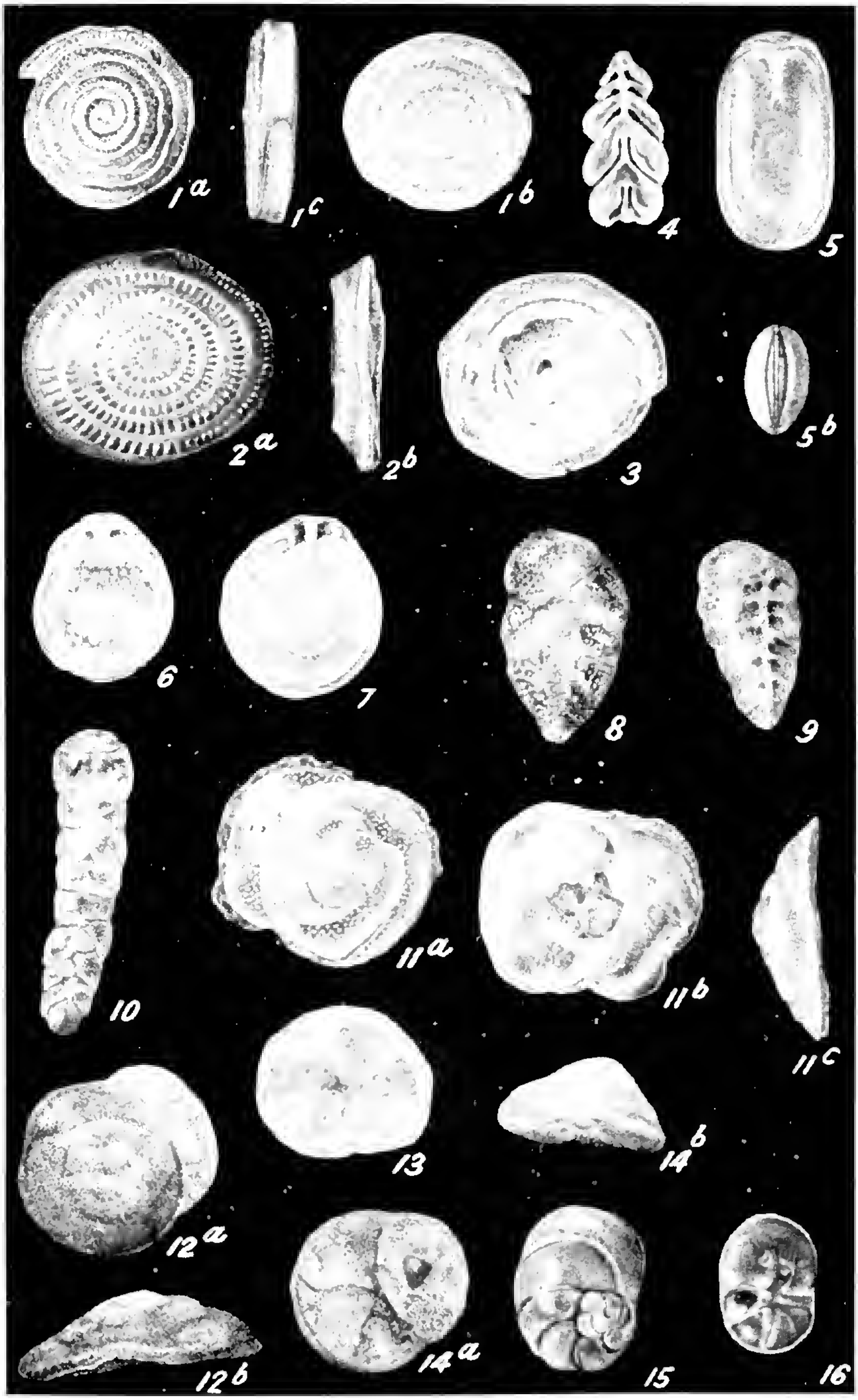
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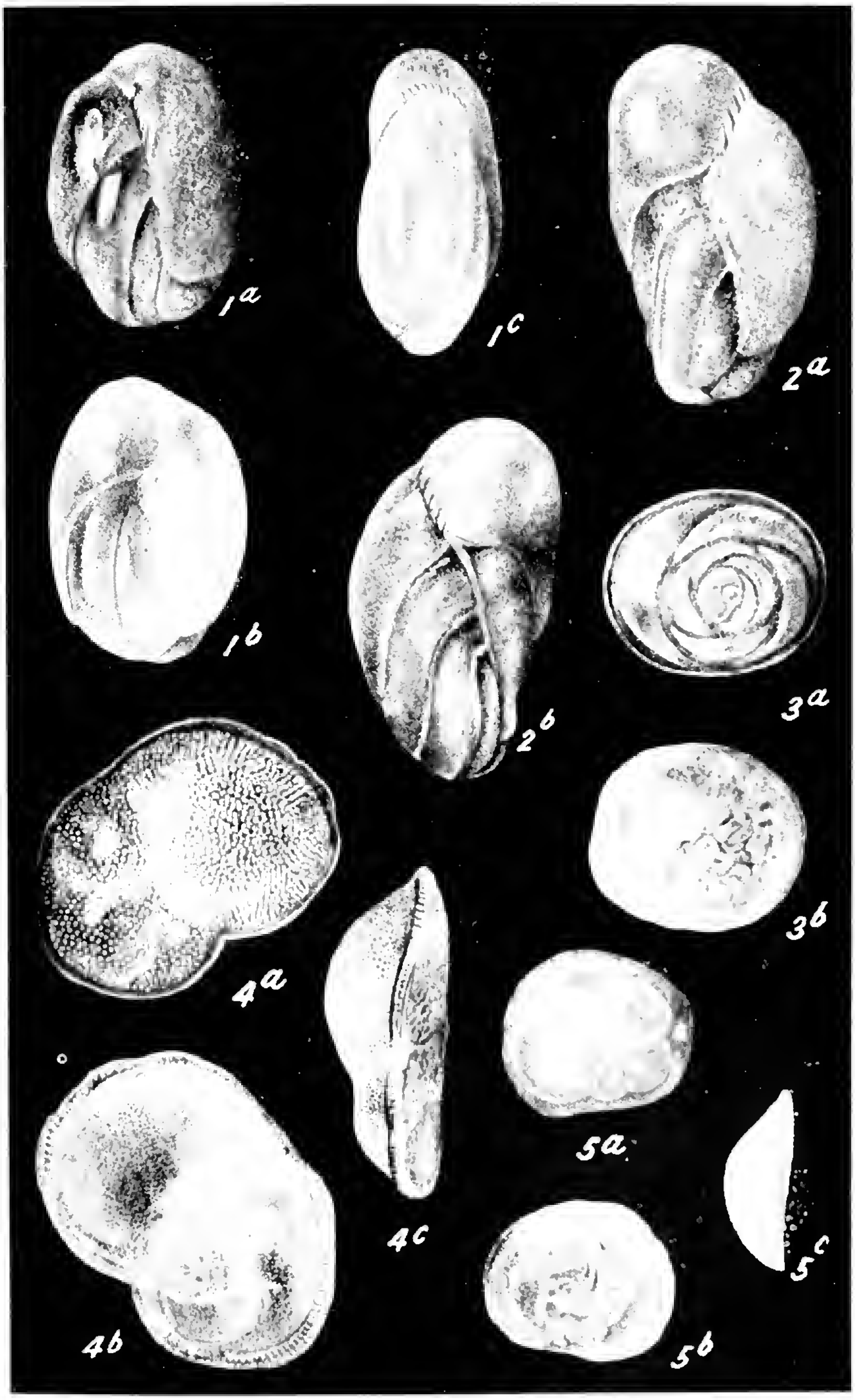
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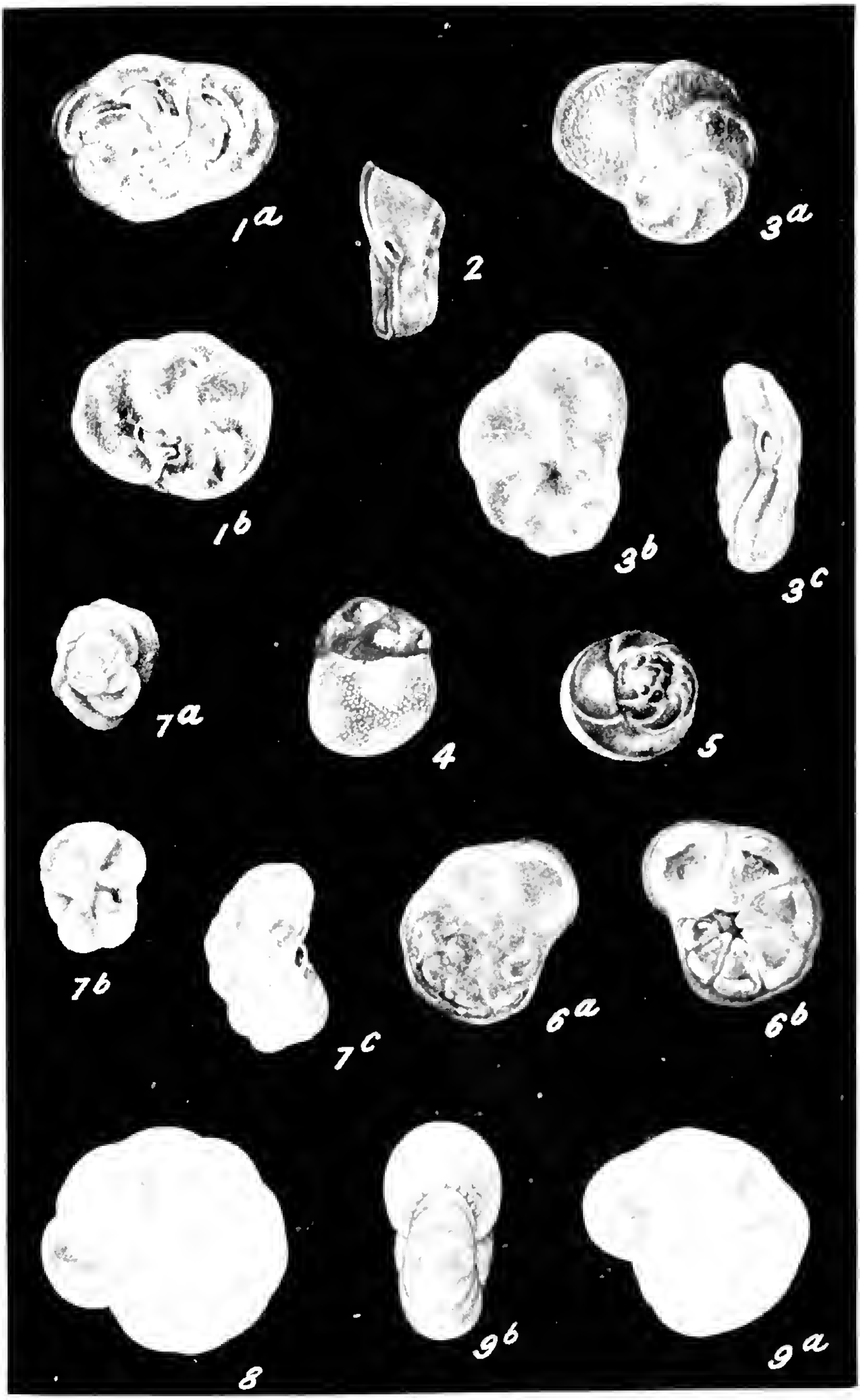
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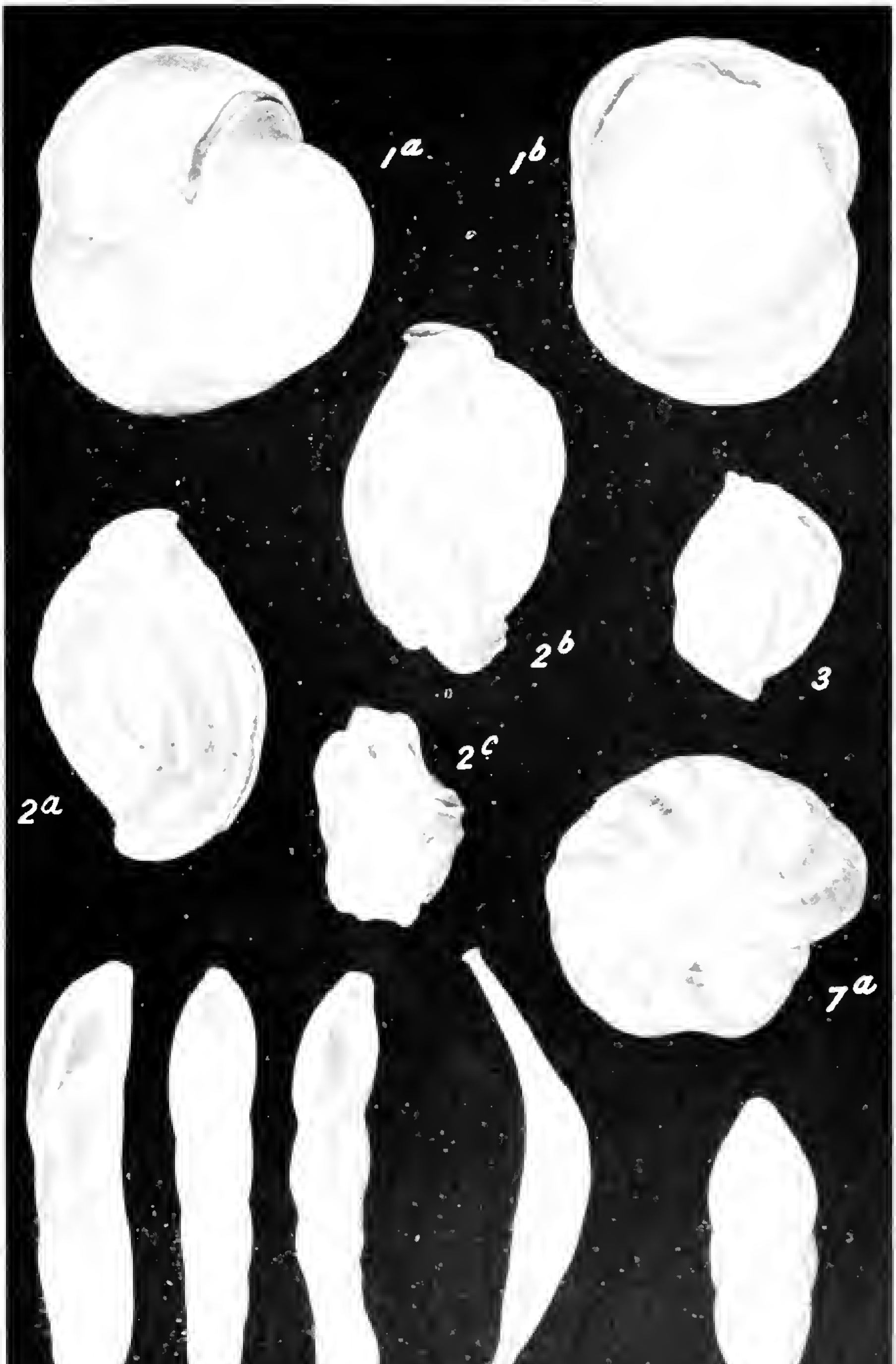
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[Proc. Roy. Soc. Victoria, 56 (N.S.), Pt. II., 1945.]

Art.—XIII.—*A Catalogue of Type and Figured Specimens of Fossils in the Melbourne University Geology Department.*

By F. A. SINGLETON, D.Sc.

[Read 9th December, 1943; issued separately 30th June, 1945.]

Abstract.

The Geological Museum of Melbourne University contains more than 200 primary or supplementary type specimens. These are listed under the appropriate species, which are arranged alphabetically under larger biological groups. For each, the literature, geological horizon, locality and source are given. The new terms, tectoholotype, tectosyntype, and tectohypotype are proposed.

Contents.

Introduction.

The importance in systematics of type material, as the ultimate basis of nomenclatural species, is now generally recognized. It follows that not only should such type material be carefully preserved in museums, but also that information as to the type specimens contained in each museum should be made generally available.

The catalogue which follows is an endeavour by the author, as curator of the Geological Museum of the University of Melbourne, Australia, to furnish this information for the primary and supplementary type specimens registered in its fossil collections. All registered fossils bear the register number in black ink or in white paint, while type specimens are distinguished by small painted discs which are red in the case of holotypes and syntypes, and green in the case of paratypes and hypotypes. Thin sections of fossils are catalogued separately and bear an independent series of register numbers, but those used in descriptions or figures (tectotypes) are marked as above.

In general, the terminology is that recommended by Frizzell (2), with the addition of Chapman's (1) terms *tectotype* and *tectoparatype*, which were not included in Frizzell's most useful list of terms, and of the new terms *tectoholotype*, *tectosyntype*, and *tectohypotype* herein proposed. These are defined together with definitions, taken from Frizzell's and Chapman's papers above cited, of the other terms used in this catalogue.

Primary Types.

Holotype—a single specimen (or fragment) upon which a species is based.

Paratype—a specimen, other than the holotype, upon which an original specific description is based.

Syntype—any specimen of the author's original material when no holotype was designated; or any of a series of specimens described as "cotypes" of equal rank.

Supplementary Types.

Hypotype—a described or figured specimen, used in publication in extending or correcting the knowledge of a previously defined species.

Plastotype—any artificial specimen moulded directly from a type.

Tectotype—a specimen, fragmentary or otherwise, which is selected to elucidate the microscopic structure, internal or external, of a species or genus (1, p. 62).

Chapman further states, "A tectotype may be associated, in the case of a species, with the original types (tectoparatype), or with subsequently described specimens (tectoplesiotype)." For this latter term is here substituted *tectohypotype*, in view of the objections to Cossmann's term plesiotype urged by Frizzell (2, pp. 653, 662). In the case of some fossils, notably the stromatoporoids, the original descriptions are commonly based entirely upon thin sections. It seems to the writer that these latter (tectotypes), when prepared from holotype or syntype material, should be termed *tectoholotypes* and *tectosyntypes*, respectively, to distinguish them from those prepared from paratypes, to which the term *tectoparatype* may be restricted. Those who disagree with this proposal will doubtless use tectoparatype to cover all three categories, and should make the necessary changes in the present catalogue, which contains, in addition to type material, figured specimens of fossils not referred to a species, and also a few Recent specimens specifically named and figured in comparison with fossils.

In each biological group the species are arranged alphabetically in order first of generic and then of trivial names. The species name in heavy face type on the left is that under which the type material listed under it was first described. It is, therefore, not necessarily (except in the case of primary types) the earliest name of the species, nor is it necessarily the correct name. Where this latter is known, it is placed on the same line on the right. In several cases, however, notably in the mollusca, the generic location is believed to require alteration but the correct genus for reception of the species has not yet been determined.

Beneath each species name are given references, not necessarily exhaustive, to the literature, and the synonymy. Then follow the register number and other details of the type material in the University of Melbourne; the geological age, not necessarily that attributed by the original author; the locality; and the source of the specimens. In a few instances, explanatory remarks are added. It has been impossible to check some of the references to overseas publications, and the author will be grateful for the pointing out of errors in these or other references.

Papers Cited.

1. F. Chapman.—What are Type Specimens? How should they be named? *Victorian Naturalist*, xxix. (4), pp. 59-64. August, 1912.

2. D. L. Frizzell.—Terminology of Types. *American Midland Naturalist*, xiv. (6), pp. 637-668, November, 1933

PLANTAE.

Antarcticoxylon Priestleyi Seward, 1914:—**Rhexoxylon Priestleyi** (Seward, 1914).

Antarcticoxylon Priestleyi A. C. Seward, Brit. Antarctic ("Terra Nova") Exped., 1910, Geology, 1 (1), p. 17, text fig. 3 (p. 6), pls. 4–7, 8 (pars), 1914.

M.U.G.D. No. 1642. Portion of Holotype in British Museum (Nat. Hist.) Lond.

(?) Permian (Beacon Sandstone series).

West side of medial moraine on Priestley Glacier, Terra Nova Bay, South Victoria Land, Antarctica.

Coll. by Northern Party, Scott's Second Expedition, and pres. by R. E. Priestley, 1935.

Obs.—A small piece from a block in the possession of Dr. Priestley, collected during extraction of the original specimen.

Calamites Macnabi Pritchard, 1910.

Calamites macnabi G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 22 (2), p. 261, April, 1910.

M.U.G.D. No. 1851. Holotype, unfigured.

Permo-Carboniferous [Permian?].

"Lower Gangamopteris quarry overlooking the Korkuperrimal Valley" (Pritchard, loc. cit., 1910) =Lower quarry (Morton's quarry), Bald Hill near Bacchus Marsh, Victoria.

The type material, which is very poorly preserved, consists of about a dozen pieces of sandstone which Dr. Pritchard (verbal communication, 11.10.39) states are all from one face of a block.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Rhexoxylon Priestleyi (Seward, 1914).

See *Antarcticoxylon Priestleyi* Seward, 1914.

PORIFERA.

Protospongia reticulata T. S. Hall, 1889.

Protospongia reticulata T. S. Hall, Proc. Roy. Soc. Vic., n.s., 1, p. 60, pl. 4, figs. 1, 2, June, 1889.

M.U.G.D. No. 1082. Holotype, figured by Hall, loc. cit., 1889.

Lower Ordovician (Bendigonian).

Ironbark, Sandhurst [= Bendigo], Victoria.

Coll. J. E. G. Edwards. Exch. with School of Mines, Bendigo.

Receptaculites australis Salter, 1859.

Receptaculites australis J. W. Salter, Figures and Descriptions of Canadian Organic Remains, Decade 1, Geol. Surv. Canada, p. 47, pl. 10, figs. 8-10, 1859. R. Etheridge and W. S. Dun, Rec. Geol. Surv. N. S. Wales, 6, p. 62, pls. 8-10, 1898. F. Chapman, Proc. Roy. Soc. Vic., n.s., 18 (1), p. 7, pl. 2, figs. 2, 4-7; pl. 3; pl. 4, figs. 2-7, 1905. J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 461, pl. 40, figs. 1-4, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 35, pl. 5, figs. 2, 4, 5, 1942.

M.U.G.D. No. 1716. Hypotype, figured by Gill, loc. cit., figs. 2, 4, 1942.

M.U.G.D. No 1717. Hypotype, counterpart of 1716, figured by Gill, loc. cit., fig. 5, 1942.

Lower Devonian (Yeringian).

Hull Road, Mooroolbark, Victoria. E. D. Gill's Locality No. 13 (Proc. Roy Soc. Vic., n.s., 52 (2), pp. 252 et seq., 1940).

Pres. Rev. E. D. Gill, 24.5.41.

STROMATOPOROIDEA.

Actinostroma compactum Ripper, 1933.

Actinostroma compactum E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 45 (2), p. 153, figs. 5A, B (p. 163), 1st August, 1933. E. A. Ripper, *ibid.*, 50 (1), p. 15, pl. 2, figs. 7, 8, 1937.

M.U.G.D. No. 767. PARATYPE, source of Fossil Sections Nos. 233, 234.

M.U.G.D. No. 767A. Vertical section of paratype No. 767.

M.U.G.D. No. 767B. Tangential section of paratype No. 767.

M.U.G.D. Fossil Section Coll. No. 233. TECTOPARATYPE, vertical section, unfigured, of paratype No. 767.

M.U.G.D. Fossil Section Coll. No. 234. TECTOPARATYPE, tangential section, unfigured, of paratype No. 767.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Sections Nos. 767A and B, though cut from the paratype, were not used in the original work and are therefore not regarded as tectoparatypes.

M.U.G.D. No. 1617. HYPOTYPE, source of Fossil Sections Nos. 154, 155.

M.U.G.D. Fossil Section Coll. No. 154. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 7, 1937, of hypotype No. 1617.

M.U.G.D. Fossil Section Coll. No. 155. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 8, 1937, of hypotype No. 1617.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, M.Sc., 1933 (Field No. 167).

Actinostroma contortum Ripper, 1937.

Actinostroma contortum E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 14, pl. 2, figs. 3-6, 29th December, 1937.

M.U.G.D. No. 1611. HOLOTYPE, source of Fossil Section No. 106.

M.U.G.D. Fossil Section Coll. No. 106. TECTOHOLOTYPE, vertical section, figured by Ripper, loc. cit., fig. 3, and tangential section, fig. 4, 1937, of holotype No. 1611.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 122).

M.U.G.D. No. 1604. PARATYPE (finer variety), source of Fossil Sections Nos. 38, 39, 41.

M.U.G.D. Fossil Section Coll. No. 38. TECTOPARATYPE, tangential section, figured by Ripper, loc. cit., fig. 6, 1937, of paratype No. 1604.

M.U.G.D. Fossil Section Coll. No. 39. TECTOPARATYPE, vertical section, figured by Ripper, loc. cit., fig. 5, 1937, of paratype No. 1604.

M.U.G.D. Fossil Section Coll. No. 41. Vertical section, unfigured, of paratype No. 1604.

Middle Devonian.

Rocky Camp, Commonwealth Quarries, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 32).

Actinostroma stellulatum Nicholson var. distans Ripper, 1937.

Actinostroma stellulatum Nicholson, variety *distans* E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 12, pl. 2, figs. 1, 2, 29th December, 1937.

M.U.G.D. No. 1610. HOLOTYPE, source of Fossil Sections Nos. 102-105.

M.U.G.D. Fossil Section Coll. No. 102. TECTOHOLOTYPE, tangential section, figured by Ripper, loc. cit., fig. 2, 1937, of holotype No. 1610.

M.U.G.D. Fossil Section Coll. No. 103. TECTOHOLOTYPE, vertical section, figured by Ripper, loc. cit., fig. 1, 1937, of holotype No. 1610.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 121).

Actinostroma verrucosum (Goldfuss, 1826).

Ceriopora verrucosa G. A. Goldfuss, Petrefacta Germaniae, 1, p. 33, pl. 10, fig. 6, 1826.

Stromatopora verrucosa Goldfuss: W. Quenstedt, Petrefakten Deutschlands, 5, p. 560, pl. 141, fig. 10, 1878. A. Bargatzky, Die Stromatoporen des rheinischen Devons, p. 55, 1881.

Actinostroma verrucosum Goldfuss: H. A. Nicholson, Ann. Nat. Hist., [5] 17, p. 228, 1886. H. A. Nicholson, Mon. Brit. Strom., pt. 2, Palaeontogr. Soc Lond., 42, for 1888, p. 134, pl. 16, figs. 1-8, 1889. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 45 (2), p. 154, text figs. 1 (p. 155), 5C, D (p. 163), 1933.

M.U.G.D. No. 1446. HYPOTYPE, source of Fossil Sections Nos. 237, 238.

M.U.G.D. Fossil Section Coll. No. 237. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 5D, 1933, of hypotype No. 1446.

M.U.G.D. Fossil Section Coll. No. 238. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., figs. 1, 5C, 1933, of hypotype No. 1446.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Coll. Miss E. A. Ripper, and pres. 24.10.32.

Clathrodictyon calamosum Ripper, 1933.

Clathrodictyon calamosum E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 45 (2), p. 160, text-figs. 6E, F (p. 164), 1st August, 1933.

M.U.G.D. No. 1448. PARATYPE, source of Fossil Sections Nos. 239, 240.

M.U.G.D. Fossil Section Coll. No. 239. Tangential section, unfigured, of paratype No. 1448.

M.U.G.D. Fossil Section Coll. No. 240. Vertical section, unfigured, of paratype No. 1448.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Coll. Miss E. A. Ripper, and pres. 24.10.32.

Clathrodictyon aff. **chapmani** Ripper, 1933.

Clathrodictyon chapmani E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 45 (2), p. 159, text-figs. 4 (p. 158), 6C, D (p. 164), 1st August, 1933.

Clathrodictyon aff. *chapmani* E. A. Ripper, *ibid.*, 50 (1), p. 3, pl. 1, figs. 3, 4, 1937.

M.U.G.D. No. 1598. HYPOTYPE, source of Fossil Sections Nos. 168, 169.

M.U.G.D. Fossil Section Coll. No. 168. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig 3, 1937, of hypotype No. 1598.

M.U.G.D. Fossil Section Coll. No. 169. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 4, 1937, of hypotype No. 1598.

Lower Devonian.

Griffith's Quarry, Allot. 131, Loyola, Victoria.

Coll Miss E. A. Ripper, 1933 (Field No. 92).

Clathrodictyon clarum Počta, 1894.

Clathrodictyon clarum P. Počta, Syst. Sil. du Centre de la Bohème, 8 (1), p. 152, pl. 18, figs. 7, 8, 1894. P. Počta, Sitzungsber. Königl. Böhm. Gesells. d. Wissensch. Prag, No. 12, p. 1 and pl., 1910. D. Le Maitre, Mém. Soc. Géol. France, n.s., 9 (1), Mém. 20, p. 16, pl. 4, figs. 1-5, 1933. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 21, pl. 4, figs. 3, 4, 1937.

M.U.G.D. No. 1605. Hypotype, source of Fossil Sections Nos. 53, 54.

M.U.G.D. Fossil Section Coll. No. 53. Tectohypotype, vertical section, figured by Ripper, loc. cit., fig. 3, 1937, of hypotype No. 1605.

M.U.G.D. Fossil Section Coll. No. 54. Tectohypotype, tangential section, figured by Ripper, loc. cit., fig. 4, 1937, of hypotype No. 1605.

Middle Devonian.

Rocky Camp, Commonwealth Quarries, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 48).

Clathrodictyon confertum Nicholson, 1889.

Clathrodictyon confertum H. A. Nicholson, Mon. Brit. Strom., pt. 2, Palaeontogr. Soc. Lond., 42, for 1888, p. 154, pl. 18, figs. 13, 14, March, 1889. K. Boehnke, Palaeontographica, 61, p. 170, figs. 15, 16, 1915. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 18, pl. 3, fig. 3, 1937.

M.U.G.D No. 1607. Hypotype, source of Fossil Sections Nos. 88, 89.

M.U.G.D. Fossil Section Coll. No. 88. Vertical section, unfigured, of hypotype No 1607.

M.U.G.D. Fossil Section Coll. No. 89. Tectohypotype, vertical section, figured by Ripper, loc. cit , 1937, of hypotype No. 1607.

Middle Devonian.

Cameron's Quarry, South Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 78).

Clathrodictyon convictum Yavorsky, 1929.

Clathrodictyon convictum B. Yavorsky, Bull. Com. Géol. Leningrad, 48 (1), pp. 91, 105, pl. 6, fig. 10; pl. 9, figs. 5-7, 1929. E. A Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 19, pl. 3, figs. 4-8, 1937.

M U.G.D. No. 1613. Hypotype, source of Fossil Sections Nos. 117, 118.

M.U.G.D. No. 1616. Hypotype, source of Fossil Sections Nos. 146, 147.

M.U.G.D. Fossil Section Coll No. 117. Tectohypotype, tangential section, figured by Ripper, loc. cit., fig. 8, 1937, of hypotype No 1613.

M.U.G.D. Fossil Section Coll. No. 118. Tectohypotype, vertical section, figured by Ripper, loc. cit., fig. 7, 1937, of hypotype No. 1613.

M.U.G.D. Fossil Section Coll. No. 146. Tectohypotype, tangential section, figured by Ripper, loc. cit., fig. 6, 1937, of hypotype No. 1616.

M.U.G.D. Fossil Section Coll. No. 147. Tectohypotype, vertical section, figured by Ripper, loc. cit., figs. 4 and 5, 1937, of hypotype No. 1616.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field Nos. 129 = Reg. No. 1613, and 157 = Reg. No. 1616).

Clathrodictyon convictum Yavorsky var. **delicatula** Ripper, 1937.

Clathrodictyon convictum Yavorsky variety *delicatula* E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 20, pl. 4, figs. 1, 2, 29th December, 1937.

M.U.G.D. No. 1606. HOLOTYPE, source of Fossil Section No. 63.

M.U.G.D. Fossil Section Coll. No. 63. TECTOHOLOTYPE, vertical section, fig. 1, and tangential section, fig. 2, figured by Ripper, loc. cit., 1937, of holotype No. 1606 (given erroneously as No. 1660 by Ripper, loc. cit., 1937, in explanation of plate 4, fig. 1).

Middle Devonian.

Rocky Camp, Commonwealth Quarries, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 56).

Clathrodictyon regulare (von Rosen, 1867).

Stromatopora regularis F. von Rosen, Ueber die Natur der Stromatoporen, p. 74, pl. 9, figs. 1-4, 1867.

Clathrodictyon regulare Rosen sp.: H. A. Nicholson, Ann. Mag. Nat. Hist., [5] 19, p. 10, pl. 2, figs. 5, 6, 1887. H. A. Nicholson, Mon. Brit. Strom., pt. 2, Palaeontogr. Soc. Lond., 42, for 1888, p. 155, pl. 18, figs. 8-11*a*, 1889. P. E. Vinassa de Regny, Palaeontographia italica, 14, p. 182, pl. 21 (1), figs. 18-20, 1908. K. Boehnke, Palaeontographica, 61, p. 168, text-fig. 12, 1915. D. Le Maitre, Mém. Soc. Géol. du Nord, 12, p. 39; p. 185, pl. 12, figs. 1-6, 1934. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 2, pl. 1, figs. 1, 2, 1937. E. A. Ripper, *ibid.*, p. 16, pl. 3, figs. 1, 2, 1937.

M.U.G.D. No. 1599. HYPOTYPE, source of Fossil Sections Nos. 175, 176.

M.U.G.D. Fossil Section Coll. No. 175. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., pl. 1, fig. 1, 1937, of hypotype No. 1599.

M.U.G.D. Fossil Section Coll. No. 176. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., pl. 1, fig. 2, 1937, of hypotype No. 1599.

Lower Devonian.

Griffith's Quarry, Allot. 131, Loyola, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 97).

M.U.G.D. No. 1618. HYPOTYPE, source of Fossil Sections Nos. 156, 157.

M.U.G.D. Fossil Section Coll. No. 156. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., pl. 3, fig. 1, 1937, of hypotype No. 1618.

M.U.G.D. Fossil Section Coll. No. 157. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., pl. 3, fig. 2, 1937, of hypotype No. 1618.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 168).

Hermatostroma episcopale Nicholson, 1892.

Hermatostroma episcopale H. A. Nicholson, Mon. Brit. Strom., pt. 4, Palaeontogr. Soc. Lond., 46, for 1892, p. 219, pl. 28, figs. 4-11, November, 1892. De Le Maitre, Mém. Soc. Géol. du Nord, 12, p. 198, pl. 15, figs. 5, 6; pl. 16, figs. 1, 2, 1934. E. A. Ripper, Proc. Roy. Soc. Vict., n.s., 50 (1), p. 29, pl. 5, figs. 7, 8, 1937.

M.U.G.D. No. 1612. HYPOTYPE, source of Fossil Sections Nos. 113, 114.

M.U.G.D. Fossil Section Coll. No. 113. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 8, 1937, of hypotype No. 1612.

M.U.G.D. Fossil Section Coll. No. 114. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 7, 1937, of hypotype No. 1612.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 126).

Hermatostroma episcopale Nicholson var. **buchanensis** Ripper, 1937.

Hermatostroma episcopale H. A. Nicholson variety *buchanensis* E. A. Ripper. Proc. Roy. Soc. Vic., n.s., 50 (1), p. 32, pl. 5, figs. 9, 10, 29th December, 1937.

M.U.G.D. No. 1602. Syntype, source of Fossil Sections Nos. 20, 21.

M.U.G.D. No. 1603. Syntype, source of Fossil Sections Nos. 27, 28.

M.U.G.D. Fossil Section Coll. No. 20. Tectosyntype, vertical section, figured by Ripper, loc. cit., fig. 9, 1937, of syntype No. 1602.

M.U.G.D. Fossil Section Coll. No. 21. Tangential section, unfigured, of syntype No. 1602.

M.U.G.D. Fossil Section Coll. No. 27. Vertical section, unfigured, of syntype No. 1603.

M.U.G.D. Fossil Section Coll. No. 28. Tectosyntype, tangential section, figured by Ripper, loc. cit., fig. 10, of syntype No. 1603.

Middle Devonian.

Near Hicks', Murrindal, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field Nos. 18 — Reg. No. 1602, and 23 — Reg. No. 1603).

Stromatopora concentrica Goldfuss, 1826.

Stromatopora concentrica G. A. Goldfuss, Petrefacta Germaniae, 1, p. 22, pl. 8, figs. 5a-c, 1826. H. A. Nicholson, Mon. Brit. Strom., pt. 1, Palaeontogr. Soc. Lond., 39, for 1885, p. 2; pl. 11, figs. 15-18, 1886. Waagen, W., and Wentzel, J., Palaeontologia Indica, series 13 (Salt-Range Fossils), 1 (7), p. 927, pl. 120, figs. 4a, b, 5a, b; pl. 121, figs. 1a-c, 1888. H. A. Nicholson, Mon. Brit. Strom., pt. 3, Palaeontogr. Soc. Lond., 44, for 1890, p. 164, pl. 20, fig. 10-12, pl. 21; figs. 1-3, pl. 24, figs. 9, 10, 1891. P. E. Vinassa de Regny, Boll. R. Com. geol. d'Ital. 41, p. 46, pl. 1, fig. 6, 1910. M. Gortani, Riv. ital. di Paleont., 18, p. 123, pl. 4, figs. 6, 7, 1912. K. Boehnke, Palaeontographica, 61, p. 180, text figs. 30, 31, 1915. P. E. Vinassa de Regny, Paleont. italica, 24, p. 113, pl. 11 (6), figs. 3-5, 1919. V. Riabinin, Bull. Unit. Geol. and Prospecting Service U.S.S.R., 51, pt. 58, p. 860, pl. 2, figs. 5, 6, 1932. D. Le Maitre, Mém. Soc. Géol. du Nord, 12, p. 197, pl. 13, figs. 6, 7, 1934. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 24, pl. 4, figs. 7, 8; pl. 5, figs. 1, 2, 1937.

M.U.G.D. No. 1608. Hypotype, source of Fossil Sections Nos. 69, 70.

M.U.G.D. Fossil Section Coll. No. 69. Tectohypotype, tangential section, figured by Ripper, loc. cit., fig. 8, 1937, of hypotype No. 1608.

M.U.G.D. Fossil Section Coll. No. 70. Tectohypotype, vertical section, figured by Ripper, loc. cit., fig. 7, 1937, of hypotype No. 1608.

Middle Devonian.

Rocky Camp, Commonwealth Quarries, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 241).

M.U.G.D. No. 1615. Hypotype, source of Fossil Sections Nos. 132, 133.

M.U.G.D. Fossil Section Coll. No. 132. Tectohypotype, tangential section, figured by Ripper, loc. cit., fig. 2, 1937, of hypotype No. 1615.

M.U.G.D. Fossil Section Coll. No. 133. Tectohypotype, vertical section, figured by Ripper, loc. cit., fig. 1, 1937, of hypotype No. 1615.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 146).

Stromatopora concentrica Goldfuss var. **colliculata** Nicholson, 1886.

Stromatopora concentrica G. A. Goldfuss variety *colliculata* H. A. Nicholson, Mon. Brit. Strom., pt. 1, Palaeontogr. Soc. Lond., 39, for 1885, pl. 3, fig. 5, January, 1886 H. A. Nicholson, *idem.*, pt. 3, *ibid.*, 44, for 1890, p. 165, 1891. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 50 (1), p. 26, pl. 5, figs. 3, 4, 1937.

M.U.G.D. No. 1614. HYPOTYPE, source of Fossil Sections Nos. 121, 122.

M.U.G.D. Fossil Section Coll. No. 121. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 3, 1937, of hypotype No. 1614.

M.U.G.D. Fossil Section Coll. No. 122 TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 4, 1937, of hypotype No. 1614.

Middle Devonian.

Heath's Quarry, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 138).

Stromatopora foveolata (Girty, 1895).

Syringostroma foveolatum G. H. Girty, Ann. Rept. New York State Mus., 48 (2), for 1894, p. 295, pl. 6, figs. 8, 9, 1895.

Stromatopora foveolata (Girty): W. A. Parks. Univ. Toronto Studies, Geol. Series 6, p. 20, pl. 17, figs. 5-7; pl. 18, figs. 4, 10, 1909. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 49 (2), p. 185, text figs. 2A, B (p. 186), 1937.

M.U.G.D. No. 768. HYPOTYPE, source of Fossil Sections Nos. 235, 236.

M.U.G.D. Fossil Section Coll. No. 235. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 2A, 1937, of hypotype No. 768.

M.U.G.D. Fossil Section Coll. No. 236. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 2B, 1937, of hypotype No. 768.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Stromatopora hüpschii (Bargatzky, 1881).

Caunopora hüpschii A. Bargatzky, Die Stromatoporen des rheinischen Devons, p. 62, 1881.

Stromatopora hüpschii Bargatzky sp.; H. A. Nicholson, Mon. Brit. Strom., pt. 1, Palaeontogr. Soc. Lond., 39, for 1885, figs. 6*a*, *b* (p. 50); pl. 10, figs. 8, 9, 1886. H. A. Nicholson, *idem*, pt. 3, *ibid.*, 44, for 1890, p. 176, fig. 20*a*, *b*, (p. 177); pl. 22, figs. 3-7, 1891. P. E. Vinassa de Regny, Palaeontographia italica, 24, p. 113, pl. 12 (7), figs. 5, 6, 1919.

Stromatopora aff. *hüpschii* (Bargatzky): E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 49 (2), p. 186, pl. 8, figs. 7, 8, 1937.

Stromatopora hüpschii (Bargatzky): E. A. Ripper, *ibid.*, 50 (1), p. 28, pl. 5, figs. 5, 6, 1937.

M.U.G.D. No. 1601. HYPOTYPE, source of Fossil Sections Nos. 3, 4.

M.U.G.D. Fossil Section Coll. No. 3. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 5, 1937, of hypotype No. 1601.

M.U.G.D. Fossil Section Coll. No. 4. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 6, 1937, of hypotype No. 1601.

Middle Devonian.

Citadel Rocks, Murrindal River, Buchan, Victoria.

Coll. Miss E. A. Ripper, 1933 (Field No. 3).

Stromatoporella granulata (Nicholson, 1873).

Stromatopora granulata H. A. Nicholson, Ann. Mag. Nat. Hist., [4] 12, p. 94, pl. 4, figs. 3, 3*a*, 1873. H. A. Nicholson, ibid., [5] 18, p. 10, 1886.

Stromatoporella granulata H. A. Nicholson, Mon. Brit. Strom., pt. 1, Palaeontogr. Soc. Lond., 39, for 1885, pl. 1, figs. 4, 5; pl. 4, fig. 6; pl. 7, figs. 5, 6, 1886. H. A. Nicholson, *idem*, pt. 3, *ibid.*, 44, for 1890, p. 202, 1891. H. A. Nicholson, *idem*, pt. 4, *ibid.*, 46, for 1892, p. 203, pl. 26, figs. 1, 1*a*, *b*, 1892. W. A. Parks, Univ. Toronto Studies, Geol. Ser., 39, p. 95, pl. 15, figs. 6, 7; pl. 16, figs. 1-7, 1936. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 49 (2), p. 191, pl. 9, figs. 3-5, 1937.

M.U.G.D. No. 1622. HYPOTYPE, source of Fossil Sections Nos. 200, 201.

M.U.G.D. Fossil Section Coll. No. 200. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 5, 1937, of hypotype No. 1622.

M.U.G.D. Fossil Section Coll. No. 201. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., figs. 3, 4, 1937, of hypotype No. 1622.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Coll. Miss E. A. Ripper.

Syringostroma densum Nicholson, 1875.

Syringostroma densa H. A. Nicholson, Rept. Geol. Surv. Ohio, 2 (2), Palaeontology, p. 251, pl. 24, figs. 2, 2*a*, *b*, 1875.

Syringostroma densum H. A. Nicholson, Mon. Brit. Strom., pt. 1, Palaeontogr. Soc. Lond., 39, for 1885, p. 97, pl. 11, figs. 13, 14, 1886. H. A. Nicholson, Ann. Mag. Nat. Hist., [6] 7, p. 326, pl. 10, figs. 8, 9, 1891. E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 49 (2), p. 182, pl. 8, figs. 3-5, 1937.

M.U.G.D. No. 1620. Hypotype, source of Fossil Sections Nos. 225, 226.

M.U.G.D. Fossil Section Coll. No. 225. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., figs. 4, 5, 1937, of hypotype No. 1620.

M.U.G.D. Fossil Section Coll. No. 226. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 3, 1937, of hypotype No. 1620.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Coll. A. C. Frostick and pres. 19.8.36.

Syringostroma aff. ristigouchense (Spencer, 1884).

Coenostroma ristigouchense Spencer, Bull. Mus. Univ. Missouri, p. 49, pl. 6, figs. 12, 12*a*, 1884.

Syringostroma ristigouchense Spencer sp., H. A. Nicholson, Mon. Brit. Strom., pt. 1, Palaeontogr. Soc. Lond., 39, for 1885, p. 97, pl. 11, figs. 11, 12, 1886. H. A. Nicholson, Ann. Mag. Nat. Hist., [6] 7, p. 324, pl. 8, figs. 6-8, 1891. W. A. Parks, Univ. Toronto Studies, Geol. Ser., 6, p. 10, pl. 16, figs. 3-5, 1909.

Syringostroma aff. *ristigouchense* (Spencer): E. A. Ripper, Proc. Roy. Soc. Vic., n.s., 49 (2), p. 181, pl. 8, figs. 1, 2, 1937.

M.U.G.D. No. 1619. HYPOTYPE, source of Fossil Sections Nos. 208, 209.

M.U.G.D. Fossil Section Coll. No. 208. TECTOHYPOTYPE, tangential section, figured by Ripper, loc. cit., fig. 2, 1937, of hypotype No. 1619.

M.U.G.D. Fossil Section Coll. No. 209. TECTOHYPOTYPE, vertical section, figured by Ripper, loc. cit., fig. 1, 1937, of hypotype No. 1619.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

A piece cut from a specimen in the collection of F. S. Colliver, Melbourne

CALYPTOBLASTEA.

Archaeocryptolaria recta Chapman, 1919.

Archaeocryptolaria recta F. Chapman, Proc. Roy. Soc. Vic., n.s., 31 (1), p. 392, pl. 19, figs. 4, 4*a*; pl. 20, fig. 8, May, 1919. F. Chapman and D. E. Thomas, *ibid.*, 48 (2), p. 198, pl. 14, fig. 1, June, 1936.

M.U.G.D. No. 527. COUNTERPART OF HOLOTYPE in National Museum, Melbourne (No. 13111), figured by Chapman, loc. cit., 1919, and by Chapman and Thomas, loc. cit., 1936.

Middle Cambrian.

Deep Creek, 2 miles ENE. of North Monegetta, Victoria.

Coll. Prof. E. W. Skeats.

Obs.—The holotype in the National Museum is Reg. No. 13111, not 1311 as stated by Chapman and Thomas.

Archaeolafoea monegettae (Chapman, 1919).

See *Mastigograptus monegettae* Chapman, 1919.

Archaeolafoea serialis Chapman and Thomas, 1936.

Archaeolafoea serialis F. Chapman and D. E. Thomas, Proc. Roy. Soc. Vic., n.s., 48 (2), p. 201, pl. 14, figs. 9-11; pl. 15, figs. 12, 12*a*, 12*b*, June, 1936.

M.U.G.D. No. 1591. PARATYPE, figured by Chapman and Thomas, loc. cit., pl. 15, figs. 12, 12*a*, 12*b*, 1936.

M.U.G.D. No. 1592. COUNTERPART OF PARATYPE NO. 1591.

Middle Cambrian.

Deep Creek, 2 miles E.N.E. of North Monegetta, Victoria.

Coll. G. Baker, 29.4.33.

Cactograptus flexispinosus Chapman and Thomas, 1936.

Cactograptus flexispinosus F. Chapman and D. E. Thomas, Proc. Roy. Soc. Vic., n.s., 48 (2), p. 207, pl. 17, figs. 29-33, June, 1936.

M.U.G.D. No. 1593. PARATYPE, figured by Chapman and Thomas, loc. cit., pl. 17, fig. 33, 1936.

M.U.G.D. No. 1594. COUNTERPART OF PARATYPE NO. 1593.

Middle Cambrian.

Deep Creek, 2 miles E.N.E. of North Monegetta, Victoria.

Coll. E. S. Hills, 29.4.33.

Mastigograptus monegettae Chapman, 1919:—Archaeolafoea monegettae (Chapman, 1919).

Mastigograptus monegettae F. Chapman, Proc. Roy. Soc. Vic., n.s., 31 (1), p. 391, pl. 19, figs. 2, 2*a*; pl. 20, fig. 6, May, 1919.

Archaeolafoea monegettae Chapman; F. Chapman and D. E. Thomas, *ibid.*, 48 (2), p. 200, pl. 14, figs. 6-8, June, 1936.

M.U.G.D. No. 528. COUNTERPART OF HOLOTYPE in National Museum, Melbourne (No. 13113), figured by Chapman, loc. cit., 1919.

Middle Cambrian.

Deep Creek, 2 miles E.N.E. of North Monegetta, Victoria.

Coll. Prof. E. W. Skeats.

GRAPTOLITOIDEA.

Climacograptus riddellensis Harris, 1924.

Diplograpsus rectangularis McCoy: F. McCoy, Prodromus Palaeont. Vic., decade 1, p. 11, pl. 11, figs. 7, 7*a*, 1874. Not *Diplograpsis* [sic] *rectangularis* M'Coy, Ann. Mag. Nat. Hist., [2] 6 (34), p. 271, 1850 [= *Climacograptus rectangularis* (McCoy)].

Climacograptus riddellensis W. J. Harris, Proc. Roy. Soc. Vic., n.s., 36 (2), p. 100, pl. 8, figs. 11, 12, August, 1924.

M.U.G.D. No. 647. COUNTERPART OF HOLOTYPE in National Museum, Melbourne, figured by Harris, loc. cit., fig. 11, 1924.

Upper Ordovician (Gisbornian).

Geol. Surv. Vic. Locality Ba 67, junction of Jackson's and Riddell's Creeks, about 3 miles south-east of Riddell railway station, Victoria.

Pres. W. J. Harris, 14.12.23.

Clonograptus flexilis (J. Hall, 1858).

Graptolithus flexilis J. Hall, Geol. Surv. Canada, Report for 1857, p. 119, 1858. J. Hall, Graptolites of the Quebec Group, Geol. Surv. Canada, decade 2, p. 103, pl. 10, figs. 3-9, 1865.

Clonograptus flexilis J. Hall: T. S. Hall, Proc. Roy. Soc. Vic., n.s., 11 (2), pl. 19, fig. 20, February, 1899. W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 1 (3), pl. 1 (p. 69), fig. 6, July, 1938.

M.U.G.D. No. 1661. HYPOTYPE, figured by T. S. Hall, loc. cit., 1899, and copied by Harris and Thomas, loc. cit., 1938.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Clonograptus magnificus (Pritchard, 1892).

See *Temnograptus magnificus* Pritchard, 1892.

Clonograptus rigidus (J. Hall, 1858).

Graptolithus rigidus J. Hall, Geol. Surv. Canada, Report for 1857, p. 121, 1858. J. Hall, Graptolites of the Quebec Group, Geol. Surv. Canada, decade 2, p. 105, pl. 11, figs. 1-5, 1865.

Clonograptus rigidus J. Hall: T. S. Hall, Proc. Roy. Soc. Vic., n.s., 11 (2), pl. 19, fig. 21, February, 1899. W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 1 (3), pl. 1 (p. 69), fig. 5, July, 1938.

M.U.G.D. No. 1660. HYPOTYPE, figured by T. S. Hall, loc. cit., 1899, and copied by Harris and Thomas, loc. cit., 1938.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Obs.—The specimen now lacks the uppermost part of T. S. Hall's figure, of which it is, however, undoubtedly the original, and is so marked in T. S. Hall's handwriting.

Dichograptus expansus Harris and Thomas, 1940.

Dichograptus expansus W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 2 (2), p. 130, pl. 1 (p. 134), fig. 5; pl. 2 (p. 135), figs. 6*a*, 6*b*, January, 1940.

M.U.G.D. No. 1678. COUNTERPART OF PARATYPE in Geol. Mus. Mines Dept. Vic. (No. 42560), figured by Harris and Thomas, loc. cit., pl. 2, fig. 6*b*, 1940.

Lower Ordovician (Bendigonian, Zone Be 2).

North-west corner of Allot. 30A, Sect. 11., Parish of Campbelltown, Victoria.

Coll. Thos. Smith, and pres. D. E. Thomas, 1939.

Dichograptus octonarius (J. Hall, 1858).

Graptolithus octonarius J. Hall, Geol. Surv. Canada, Report for 1857, p. 124, 1858. J. Hall, Graptolites of the Quebec Group, Geol. Surv. Canada, decade 2, p. 95, pl. 10, figs. 1, 2, 1865.

Dichograptus octonarius (J. Hall): W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 2 (2), p. 129. pl. 1 (p. 134), figs. *2a, 2b*; pl. 2 (p. 135), fig. 3, January, 1940.

M.U.G.D. No. 1679. COUNTERPART OF HYPOTYPE in Geol. Mus. Mines Dept. Vic. (No. 42553), figured by Harris and Thomas, loc. cit., pl. 1, fig. *2a;* pl. 2, fig. 3, 1940.

Lower Ordovician (Castlemainian, Zone Ca 2).

Victoria Gully, Castlemaine, Victoria.

Pres. D. E. Thomas, 1939.

Dichograptus octonarius (J. Hall) var. **solida,** Harris and Thomas, 1940.

Dichograptus octonarius var. *solida* W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 2 (2), p. 130. pl. 1, fig. 3; pl. 2, fig. 4, January, 1940.

M.U.G.D. No. 1680. COUNTERPART OF HOLOTYPE of variety in Geol. Mus. Mines Dept. Vic. (No. 42555), figured by Harris and Thomas, loc. cit., 1940.

Lower Ordovician (Yapeenian, Zone Ya 2).

Wiley's Quarry, Woodend, Victoria.

Pres. D. E. Thomas, 1939.

Dictyonema grande T. S. Hall, 1892.

See *Dictyonema macgillivrayi* T. S. Hall, 1897.

Dictyonema macgillivrayi T. S. Hall, 1897.

Dictyonema grande T. S. Hall, Proc. Roy. Soc. Vic., n.s., 4 (1), p. 8, pls. 1, 2, April, 1892. G. B. Pritchard, *ibid.*, 7, p. 28, January, 1895. Not *Dictyonema grandis* H. A. Nicholson, Ann. Mag. Nat. Hist., [4] 11 (62), p. 134, text figs. *1a, 1b* (p. 135), 1873.

Dictyonema macgillivrayi T. S. Hall, nom. mut., Proc. Roy. Soc. Vic., n.s., 10 (1), p. 15, July, 1897. T. S. Hall, *ibid.*, 11 (2), p. 174, pl. 18, fig. 27, February, 1899. W. J. Harris and R. A. Keble, *ibid.*, 44 (1), p. 47, pl. 3, February, 1932.

M.U.G.D. No. 1664. HYPOTYPE, figured (in part) by T. S. Hall, loc. cit., 1899, and counterpart of hypotype in National Museum, Melbourne (No. 13126), figured by Harris and Keble, loc. cit., 1932. It is also the basis of the description by Pritchard, loc. cit., 1895.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Dictyonema pulchellum T. S. Hall, 1899.

Dictyonema pulchellum T. S. Hall, Proc. Roy. Soc. Vic., n.s., 11 (2), p. 174, pl. 18, figs. 28-30, February, 1899.

M.U.G.D. No. 1656. SYNTYPE, figured by T. S. Hall, loc. cit., pl. 18, fig. 28, 1899.

M.U.G.D. No. 1657. SYNTYPE, figured by T. S. Hall, loc. cit., pl. 18, figs. 29, 30, 1899.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Didymograptus ensjoensis Monsen, 1937.

Didymograptus ensjoensis A. Monsen, Sond. ans. Norsk. Geol. Tidssk., 16, pl. 1, fig. 40; pl. 7, figs. 12, 14, 1937. W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 2 (2), p. 133, pl. 1, figs. 13*a*, 13*b*; pl. 2, figs. 15*a*, 15*b*, January, 1940.

M.U.G.D. No. 1681. COUNTERPART OF HYPOTYPE in Geol. Mus. Mines Dept. Vic. (No. 43206), figured by Harris and Thomas, loc. cit., pl. 1, fig. 13*a*; pl. 2, fig. 15*a*, *b*, 1940.

Lower Ordovician (Bendigonian, Zone Be 2).

North-west corner of Allot. 30A, Sect. 11., Parish of Campbelltown, Victoria.

Coll. Thos. Smith, and pres. D. E. Thomas, 1939.

Didymograptus taylori T. S. Hall, 1899.

Didymograptus taylori T. S. Hall, Proc. Roy. Soc. Vic., n.s., 11 (2), p. 167, pl. 17, figs. 11, 12, February, 1899.

M.U.G.D. No. 1658. HOLOTYPE, figured by T. S. Hall, loc. cit., 1899.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Goniograptus (?)velatus Harris and Thomas, 1939.

Goniograptus velatus W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 2 (1), p. 57, text figs. 8, 9, July, 1939.

M.U.G.D. No. 1097. PARATYPE, figured by Harris and Thomas, loc. cit., text fig. 9, 1939.

Lower Ordovician (Bendigonian, Zone Be 3).

East side of Jim Crow Creek, 100 yards north of Tipperary Spring, Daylesford, Victoria.

Coll. J. O'M. Lyons and pres. 10.11.30.

Monograptus crinitus Wood, 1900.

Monograptus crinitus E. M. R. Wood, Quart. Journ. Geol. Soc. London, 56 (2), p. 480, text figs. 23*a-d* (p. 481), pl. 25, figs. 26*a*, 26*b*, May, 1900. G. L. Elles and E. M. R. Wood, British Graptolites, pt. 9, Mon. Pal. Soc., 66, p. 435, text figs. 298*a-c*, pl. 44, figs. 3*a-c*, February, 1913. W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 1 (1), p. 74, pl. 2, fig. 31, July, 1937.

M.U.G.D. No. 1596. COUNTERPART OF HYPOTYPE No. 1597.

M.U.G.D. No. 1597. HYPOTYPE, figured by Harris and Thomas, loc. cit., 1937.

Upper Silurian (Melbournian).

Track to pumping station, Studley Park, Melbourne, Victoria.

Coll. E. S. Hills and pres. 1936.

Monograptus turriculatus (Barrande, 1850).

Graptolithus turriculatus Barrande, Grapt. de Bohême, p. 56, pl. 4, figs. 7-11, 1850.

Monograptus turriculatus (Barrande): G. L. Elles and E. M. R. Wood, British Graptolites, pt. 9, Mon. Pal. Soc., 66, p. 438, text figs. 301*a-c*, pl. 44, figs. 4*a-c* February, 1913. T. S. Hall, Proc. Roy. Soc. Vic., n.s., 27 (1), p. 114, pl. 17, figs. 18, 19, September, 1914.

M.U.G.D. No. 539. COUNTERPART OF HYPOTYPE No. 540.

M.U.G.D. No. 540. HYPOTYPE, figured by T. S. Hall, loc. cit., 1914.

Lower Silurian (Keilorian).

Aplin's section, the Monocline, Keilor, Victoria.

Coll. Prof. E. W. Skeats.

Monograptus uncinatus Tullberg var. **orbatus** Wood, 1900.

Monograptus uncinatus variety *orbatus* E. M. R. Wood, Quart. Journ. Geol. Soc. London, 56 (2), p. 476, text figs. *20a*, *20b*, pl. 25, figs. *23a*, *23b*, May, 1900. G. L. Elles and E. M. R. Wood, British Graptolites, pt. 9, Mon. Pal. Soc., 66, p. 427, text figs. *290a*, *290b* (p. 428), pl. 43, figs. *1a-d*, February, 1913. W. H. Lang and I. C. Cookson, Phil. Trans. Roy. Soc. London, Ser. B. No. 517, vol. 224, p. 422 (citation), March, 1935. W. J. Harris and D. E. Thomas, Min. and Geol. Journ., Vic., 1 (1), p. 73, pl. 2, figs. 23-29, July, 1937.

M.U.G.D., No. 1572. Hypotype, figured by Harris and Thomas, loc. cit., fig. *23*, 1937.

M.U.G.D. No. 1575. Counterpart of hypotype No. 1572.

Upper Silurian (Zone of *Monograptus nilssoni*).

Geol. Surv. Vic. Loc. 9, Railway Cutting, between 2¼ and 2½ miles from Alexandra, Victoria.

Obs.—This is on the slab the graptolites of which were identified by Dr. G. L. Elles in 1934 and cited by Lang and Cookson, loc. cit., 1935. The locality was erroneously cited by Harris and Thomas, loc. cit., 1937, as "19-mile Quarry, Yarra Track." (*Fide* these authors, op. cit, 2 (5), p. 305 and footnote, 1941.)

Temnograptus magnificus Pritchard, 1892:—**Clonograptus magnificus** (Pritchard, 1892).

Temnograptus magnificus G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 4 (1), p. 56, pl. 6, figs. 1-3, April, 1892. Pritchard, *ibid.*, 7, p. 29, January, 1895.

Clonograptus magnificus Pritchard: T. S. Hall, *ibid.*, 11 (2), p. 170, February, 1899.

M.U.G.D. No. 1665. Holotype, figured by Pritchard, loc. cit., 1892.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Obs.—The type specimen, measuring about one metre in diameter, is probably the largest known Victorian graptolite.

Tetragraptus decipiens T. S. Hall, 1899.

Tetragraptus decipiens T. S. Hall, Proc. Roy. Soc. Vic., n.s., 11 (2), p. 168, pl. 17, figs. 13-15; pl. 18, figs. 16-19, February, 1899. R. A. Keble, Rec Geol. Surv. Vic., 4 (2), p. 199, pl. 34, 1920.

M.U.G.D. No. 1663. Paratype, figured by T. S. Hall, loc. cit., pl. 18, fig. 16, 1899.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Obs.—This specimen, though referred to the above species by Hall (loc. cit., p. 178), bears six stipes and thus should be excluded from *Tetragraptus*. An accompanying specimen with five stipes (No. 1662) purchased from Dr. Pritchard, and from the same locality, was labelled "figd. T.S.H.", but apparently it was never figured by Dr. T. S. Hall.

ANTHOZOA.

Acanthophyllum mansfieldense (Dun, 1898).

Cyathophyllum mansfieldense W. S. Dun, Proc. Roy. Soc. Vic., n.s., 10 (2), p. 87, pl. 3, figs. 3, 4, May, 1898.

Acanthophyllum mansfieldense (Dun): D. Hill, *ibid.*, 51 (2), p. 223, pl. 15, figs. 1-3, July, 1939.

M.U.G.D. No. 1646. HYPOTYPE, source of Fossil Section No. 610.

M.U.G.D. No. 1653. HYPOTYPE, source of Fossil Sections Nos. 608, 609.

M.U.G.D. Fossil Section Coll. No. 608. TECTOHYPOTYPE, transverse section, figured by D. Hill, loc. cit., figs. 1*a*, 1*b*, 1939, of hypotype No. 1653.

M.U.G.D. Fossil Section Coll. No. 609. TECTOHYPOTYPE, vertical section, figured by D. Hill, loc. cit., fig. 2, 1939, of hypotype No. 1653.

M.U.G.D. Fossil Section Coll. No. 610. TECTOHYPOTYPE, transverse section, figured by D. Hill, loc. cit., fig. 3, 1939, of hypotype No. 1646.

This and the preceding are the basis of the description by Dr. D. Hill, loc. cit., p. 223, 1939.

Lower Devonian.

Quarry, Allot. 94, Parish of Loyola, Victoria.

Coll. Miss E. A. Ripper and pres. 27.6.33.

Acervularia chalkii Chapman, 1931:—Prismatophyllum chalkii (Chapman, 1931).

Acervularia chalkii F. Chapman, Vic. Naturalist, 48 (5), p. 94, text fig., September, 1931.

Prismatophyllum chalkii (Chapman): D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 232, pl. 13, figs. 1-5, July, 1939.

M.U.G.D. No. 1877. HOLOTYPE, figured by Chapman, *loc. cit.*, 1931, and by Hill, loc. cit., fig. 1, 1939.

Coll. A. S. Chalk, and pres. W. D. Chapman, 23.10.44.

M.U.G.D. No. 1654. HYPOTYPE, formerly Univ. Qld. Geol. Dept. No. F3252, and source of Fossil Sections Nos. 626, 627.

M.U.G.D. No. 1655. HYPOTYPE, formerly Univ. Qld. Geol. Dept. No. F3253, and source of Fossil Sections Nos. 628, 629. This and the preceding are referred to by D. Hill, loc. cit., p. 233, 1939.

M.U.G.D. Fossil Section Coll. No. 626. TECTOHYPOTYPE, transverse section, figured by D. Hill, loc. cit., fig. 2, 1939, of hypotype No. 1654.

M.U.G.D. Fossil Section Coll. No. 627. TECTOHYPOTYPE, vertical section, figured by D. Hill, loc. cit., fig. 5, 1939, of hypotype No. 1654.

M.U.G.D. Fossil Section Coll. No. 628. TECTOHYPOTYPE, oblique section, figured by D. Hill, loc. cit., fig. 3, 1939, of hypotype No. 1655.

M.U.G.D. Fossil Section Coll. No. 629. TECTOHYPOTYPE, oblique section, figured by D. Hill, loc. cit., fig. 4, 1939, of hypotype No. 1655.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Coll. Dr. D. Hill and pres. 19.4.39.

Columnaria (Loyolophyllum) cresswelli Chapman, 1914.

See *Loyolophyllum cresswelli* Chapman, 1914.

Cyathophyllum cresswelli Chapman, 1925.

See *Mictophyllum cresswelli* (Chapman, 1925).

Cyathophyllum elegantulum Dun, 1898.

See *Trapezophyllum elegantulum* (Dun, 1898).

Cyathophyllum mansfieldense Dun, 1898.

See *Acanthophyllum mansfieldense* (Dun, 1989).

Cyathophyllum subcaespitosum Chapman, 1925.

See *Lyriclasma subcaespitosum* (Chapman, 1925).

" **Cystiphyllum** " sp.

" *Cystiphyllum* " sp.: D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 250, pl. 15, figs. 4, 5, 1939.

M.U.G.D. No. 1652. FIGURED SPECIMEN, source of Fossil Section No. 620.

M.U.G.D. Fossil Section Coll. No. 620. FIGURED SPECIMEN, transverse section (fig. 4), and vertical section (fig. 5), figured by Hill, loc. cit., 1939, of specimen No. 1652. Dr. Hill refers to the originals of figs. 4 and 5 as Nos. 620A and 620B, respectively, but both are on the one slide, numbered 620.

Lower Devonian.

"Loyola" (Hill, loc. cit., p. 250, 1939) Quarry, Allot. 94, Parish of Loyola, Victoria.

Coll. Miss E. A. Ripper, and pres. 27.6.33.

Loyolophyllum cresswelli (Chapman, 1914).

Columnaria (Loyolophyllum) cresswelli F. Chapman, Rec. Geol. Surv. Vic., 3 (3), p. 306, pl. 51, figs. 15, 16; pl. 52, figs. 17, 18, 1914.

Loyolophyllum cresswelli Chapman: R. Etheridge, jun., Rec. Aust. Mus., 12, p. 51, 1918. D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 242, pl. 15, figs. 8-11, 1939.

M.U.G.D. No. 1644. HYPOTYPE, source of Fossil Section No. 616.

M.U.G.D. No. 1650. HYPOTYPE, source of Fossil Section No. 618.

M.U.G.D. No. 1651. HYPOTYPE, source of Fossil Section No. 617.

M.U.G.D. Fossil Section Coll. No. 616. TECTOHYPOTYPE, transverse section, figured by Hill, loc. cit., fig. 8, 1939, of hypotype No. 1644.

M.U.G.D. Fossil Section Coll. No. 617. TECTOHYPOTYPE, oblique section, figured by Hill, loc. cit., fig. 9, 1939, of hypotype No. 1651.

M.U.G.D. Fossil Section Coll. No. 618. TECTOHYPOTYPE, vertical section, figured by Hill, loc. cit., fig. 10, 1939, of hypotype No. 1650.

M.U.G.D. Fossil Section Coll. No. 619. TECTOHYPOTYPE, transverse section, figured by Hill, loc. cit., fig. 11, 1939, source unknown.

Lower Devonian.

Griffith's Quarry, Loyola, Victoria.

Coll. Miss E. A. Ripper, and pres. 27.6.33.

Lyrielasma subcaespitosum (Chapman, 1925).

Cyathophyllum subcaespitosum F. Chapman, Proc. Roy. Soc. Vic., n.s., 37 (1), p. 112, pl. 13, figs. 15, 16*a*, *b*, 25th May, 1925.

Lyrielasma subcaespitosum (Chapman): D. Hill, *ibid.*, 51 (2), p. 244, pl. 14, figs. 1-6; pl. 15, figs. 6, 7, 1939.

M.U.G.D. Fossil Section Coll. No. 621. Tectohypotype, transverse section, figured by Hill, loc. cit., pl. 15, fig. 6, 1939.

M.U.G.D. Fossil Section Coll. No. 622. Tectohypotype, transverse section, figured by Hill, loc. cit., pl. 15, fig. 7, 1939. The original specimen was destroyed in the making of the above slides.

Lower Devonian.

Griffith's Quarry, Loyola, Victoria.

Coll. Miss E. A. Ripper, and pres. 27.6.33.

Mictophyllum cresswelli (Chapman, 1925).

Cyathophyllum cresswelli F. Chapman, Proc. Roy. Soc. Vic., n.s., 37 (1), p. 111, pl. 13, figs. 11-14, May, 1925.

Mictophyllum cresswelli (Chapman): D. Hill, *ibid.*, 51 (2), p. 246, pl. 14, figs. 7-11, July, 1939.

M.U.G.D Fossil Section Coll. No. 630. Tectohypotype, vertical section, figured by D. Hill, loc. cit., fig. 9, 1939, of Univ. Qld Geol. Dept. No. F3289.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Coll. Dr. D. Hill and pres. 19.4.39.

Phillipsastraea speciosa Chapman, 1914.

Phillipsastraea speciosa F. Chapman, Rec. Geol. Surv. Vic., 3 (3), p. 306, pl. 49, figs. 10, 11; pl. 50, figs. 12-14, 1914. D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 237, pl. 16, figs. 1-4, 1939.

M.U.G.D No. 1648. Hypotype, source of Fossil Section No. 612.

M.U.G.D. No. 1649. Hypotype, source of Fossil Section No. 611.

M.U.G.D. Fossil Section Coll. No. 611. Tectohypotype, transverse and part of a vertical section, figured by Hill, loc. cit., fig. 3, 1939, of hypotype No. 1649.

M.U.G.D. Fossil Section Coll. No. 612. Tectohypotype, vertical section, figured by Hill, loc. cit., fig. 4, 1939, of hypotype No. 1648.

Lower Devonian.

Loyola, Victoria.

Coll. Miss E. A. Ripper, and pres. 27.6.33.

Pleurodictyum megastomum Dun, 1898.

Pleurodictyum problematicum Goldfuss ?: A. F. Foerste, Bull. Sci. Lab. Denison Univ., 3 (2), p. 132, pl. 13, fig. 22, 1888. Not *Pleurodictyum problematicum* G. A. Goldfuss, Petref. Germ., 1 (2), p. 113, pl. 43, figs. 18*a-d*, 1829.

Pleurodictyum, sp. (?*P. megastomum*, McCoy, MS.): W. S. Dun, Proc. Roy. Soc. Vic., n.s., 10 (2), p. 83, pl. 3, fig. 1, May, 1898.

Pleurodictyum megastomum Dun: F. Chapman, *ibid.*, 15 (2), p. 105, pl. 16, figs. 2-5, 1903. F. Chapman, *ibid.*, 33, p. 216, pl. 9, figs. 4-6, 1921. R. S. Allan, Trans. N.Z. Inst., 60 (2), p. 322, 1929. R. B. Withers Proc. Roy. Soc. Vic., n.s., 44 (1), p. 15, text figs. 1-6, 1932. J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 463, pl. 40, figs. 5-8, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 35, pl. 4, figs. 1, 3, 4, 6, 9, 1942.

M.U.G.D. No. 1711. Hypotype, mould of corallites, figured by Gill, loc. cit., fig. 1, 1942.

M.U.G.D. No. 1712. HYPOTYPE, epitheca on *Spirifer,* counterpart of No. 1711, figured by Gill, loc. cit., fig. 3, 1942.

Lower Devonian (Yeringian).

North of Lilydale, Victoria. E. D. Gill's Locality No. 3 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252, 258, 1940).

Pres. Rev. E. D. Gill, 24.5.41.

M.U.G.D. No. 1713. HYPOTYPE, mould of corallites, nineteen-celled form, figured by Gill, loc. cit., fig. 4, 1942.

M.U.G.D. No. 1714. HYPOTYPE, three-celled form, figured by Gill, loc. cit., fig. 6, 1942.

Lower Devonian (Yeringian).

Syme's Tunnel, Killara, Victoria.

Pres. Rev. E. D. Gill, 24.5.41.

Prismatophyllum chalkii (Chapman, 1931).

See *Acervularia chalkii* Chapman, 1931.

Prismatophyllum stevensi (Chapman, 1925).

See *Spongophyllum stevensi* Chapman, 1925.

Rugose Coral, gen. et. sp. indet.

Gen. et sp. indet.: D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 256, pl. 15, fig. 12, 1939.

M.U.G.D. Fossil Section Coll. No. 623. FIGURED SPECIMEN, oblique section, figured by Hill, loc. cit., 1939. The original specimen was destroyed in the process of making the slide.

Lower Devonian.

Loyola, Victoria.

Coll. Miss E. A. Ripper, and pres. 27.6.33.

Spongophyllum stevensi Chapman, 1925:—**Prismatophyllum stevensi** (Chapman, 1925).

Spongophyllum stevensi F. Chapman, Proc. Roy. Soc. Vic., n.s., 37 (1), p. 113, pl. 14, figs. 17*a*, 17*b*; pl. 15, figs. 24, 27. May, 1925. O. A. Jones, Proc. Roy. Soc. Qld., 44, p. 52, March, 1933.

Prismatophyllum stevensi (Chapman): D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 231, pl. 13, figs. 6, 7, July, 1939.

M.U.G.D. No. 797. PORTION OF HOLOTYPE in National Museum, Melbourne (No. 13305), figured by Chapman, loc. cit., 1925.

M.U.G.D. No 797A. Polished piece cut from No. 797.

M.U.G.D. No. 797B. Transverse slice cut from holotype.

M.U.G.D. Fossil Section Coll. No. 624. TECTOHYPOTYPE, vertical section of holotype, cut from No. 797A, and figured by D. Hill, loc. cit., fig. 6, 1939.

M.U.G.D. Fossil Section Coll. No. 625. TECTOHYPOTYPE, transverse section of holotype, cut from No. 797A, and figured by D. Hill, loc. cit., fig. 7, 1939.

Lower Devonian (Yeringian).

Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Pres. L. E. Stevens, 8.8.21.

Trapezophyllum elegantulum (Dun, 1898).

Cyathophyllum elegantulum W. S. Dun, Proc. Roy. Soc. Vic., n.s., 10 (2), p. 85, pl. 3, figs. 5, 6, May, 1898.

Cyathophyllum? elegantulum Dun: R. Etheridge, jun., Prog. Rept. Geol. Surv. Vic., 11, p. 31, pl. B, figs. 2-4, 1899.

Cyathophyllum (Trapezophyllum) elegantulum Dun: R. Etheridge, jun., *ibid.*, p. 32, 1899.

Trapezophyllum elegantulum (Dun): D. Hill, Proc. Roy. Soc. Vic., n.s., 51 (2), p. 235, pl. 16, figs. 9-11, 1939.

M.U.G.D. No. 1647. Hypotype, source of Fossil Sections Nos. 613, 614.

M.U.G.D. Fossil Section Coll. No. 613. Tectohypotype, transverse section, figured by Hill, loc. cit., fig. 9, 1939, of hypotype No. 1647.

M.U.G.D. Fossil Section Coll. No. 614. Tectohypotype, vertical section, figured by Hill, loc. cit., fig. 10, 1939, of hypotype No. 1647.

M.U.G.D. Fossil Section Coll. No. 615. Tectohypotype, vertical section, figured by Hill, loc. cit., fig. 11, 1939. No specimen is known from which this slide was prepared.

Lower Devonian.

Loyola, Victoria.

Coll. Miss E. A. Ripper, and pres. 27.6.33.

ASTEROIDEA.

Eospondylus tenuis Withers and Keble, 1934.

Eospondylus tenuis R. B. Withers and R. A. Keble, Proc. Roy. Soc. Vic., n.s., 47 (1), p. 206, pl. 11, fig. 7 and text fig. 12 on p. 211. 22nd December, 1934.

M.U.G.D. No 1497. Holotype, oral aspect, figured by Withers and Keble, loc. cit., 1934.

"Silurian (Yarravian Series)" (Withers and Keble, loc. cit., p. 207, 1934) Upper Silurian (Melbournian).

"Moonee Ponds" (Withers and Keble, loc. cit., p. 207, 1934) Cliff section, N. of Brunswick Road bridge, Moonee Ponds Creek, West Brunswick, Victoria.

Collected by E. S. Hills, 1926.

Furcaster bakeri Withers and Keble, 1934.

Furcaster bakeri R. B. Withers and R. A. Keble, Proc. Roy. Soc. Vic., n.s., 47 (1), p. 204, pl. 11, figs. 9, 10 and text figs. 10, 11 on p. 211, 22nd December, 1934.

M.U G.D. No. 1498. Syntype, oral aspect, figured by Withers and Keble, loc. cit., fig. 9 and text fig. 10, 1934.

M.U.G.D. No. 1499 Syntype, aboral aspect (counterpart of No. 1498) figured by Withers and Keble, loc. cit., fig. 10 and text fig. 11, 1934.

"Silurian (Yarravian)" (Withers and Keble, loc. cit., p. 205, 1934) = Upper Silurian (Melbournian).

East side of new Yarra Boulevard, vicinity of Dight's Falls, Studley Park, Victoria. The specimen was not *in situ*.

Collected by G. Baker, 27.1.34.

Hallaster parvus Withers and Keble, 1934.

Taeniaster (?) aff. *spinosus* Billings: E. S. Hills, Proc. Roy. Soc. Vic., n.s., 41 (2), p. 179, 1929 (list name). Not *Taeniaster spinosus* E. Billings, Geol. Surv. Canada, Canadian Organic Remains, decade 3, p. 81, pl. 10, figs. *3a-d*, 1858.

Hallaster parvus R. B. Withers and R. A. Keble, Proc. Roy. Soc. Vic., n.s., 47 (1), p. 203, pl. 11, figs. 5, 6, text figs. 8, 9 on p. 211, 22nd December, 1934.

M.U.G.D. No. 792. Syntype, oral aspect, figured by Withers and Keble, loc. cit., fig. 5 and text fig. 8, 1934.

M.U.G.D. No. 793. Syntype, aboral aspect (counterpart of No. 792), figured by Withers and Keble, loc. cit., fig. 6 and text fig. 9, 1934.

Silurian.

Blue Hills, Taggerty, Victoria.

Presented by E. S. Hills, 20.2.29.

Lapworthura pulcherrima Withers and Keble, 1934.

Lapworthura pulcherrima R. B. Withers and R. A. Keble, Proc. Roy. Soc. Vic., n.s., 47 (1), p. 201, pl. 11, figs. 1, 2 and text figs. 4, 5 on p. 201, 22nd December, 1934.

M.U.G.D. No. 1157. Syntype, aboral aspect, figured by Withers and Keble, loc. cit., fig. 1 and text fig. 4, 1934.

M.U.G.D. No. 1500. Syntype, oral aspect (counterpart of No. 1157), figured by Withers and Keble, loc. cit., fig. 2 and text fig. 5, 1934.

"Silurian (Yarravian Series)" (Withers and Keble, loc. cit., p. 202, 1934) = Upper Silurian (Melbournian).

"Dawson-street, West Brunswick, about quarter of a mile north of the Geological Survey of Victoria Locality Flemington (B8)" (Withers and Keble, loc. cit., p. 202, 1934), Victoria. The specimen came from a sewerage tunnel on the east side of Moonee Ponds Creek (D. McCance, personal communication).

Presented by D. M. McCance, July, 1927.

ECHINOIDEA.

Linthia mooraboolensis Pritchard, 1908.

Linthia mooraboolensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 21 (1), p. 394, pl. 22, figs. 1, 2; pl. 23, figs. 3, 4, August, 1908.

M.U.G.D. No. 1689. Holotype, figured by Pritchard, loc. cit., 1908.

Miocene (Batesfordian).

Filter Quarries (limestones), Moorabool River near Batesford, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

cf. **Lovenia** sp.

cf. *Lovenia* F. Chapman, Vic. Naturalist, 39 (11), p. 158, pl. 4, 2 figs., 8th March, 1923

M.U.G.D. No. 555. Figured specimen, internal cast, figured by Chapman, loc. cit., 1923.

Lower Pliocene (Kalimnan?).

Sand-pit, Studley Park, Kew, Victoria.

Collected on geological excursion of Melbourne University students, 1917.

BRACHIOPODA.

Anoplia australis Gill, 1942.

Anoplia australis E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 38, pl. 4, fig. 8, 15th April, 1942.

M.U.G.D. No. 1720. HOLOTYPE, internal casts of dorsal and ventral valves, figured by Gill, loc. cit., 1942.

Lower Devonian (Yeringian).

Quarry in impure limestone, south side of Warburton highway, Seville, Victoria. Military Survey of Victoria, Ringwood Sheet, reference 497, 413.

Pres. Rev. E. D. Gill, 24.5.41.

Anoplia withersi Gill, 1942.

Anoplia withersi E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 39, pl. 4, fig. 7, 15th April, 1942.

M.U.G.D. No. 1721. HOLOTYPE, internal cast of ventral valve, figured by Gill, loc cit., 1942.

Lower Devonian (Yeringian).

Syme's Tunnel, Killara, Victoria.

Pres. Rev. E. D. Gill, 24.5.41.

Chonetes bipartita Chapman, 1913.

See *Stropheodonta bipartita* (Chapman, 1913).

Cyrtinopsis perlamellosus (J. Hall, 1857).

Spirifer perlamellosa J. Hall, Tenth Ann. Rept. New York State, Cabinet Nat. Hist., p. 57, figs. 1, 2, 1857.

Spirifer perlamellosus J. Hall, Nat. Hist. New York, Palaeont., 3, p. 201, pl. 26, figs. 1a-e, 2a-a, 1859. J. Hall and J. M. Clarke, Nat. Hist. New York, pt. 6, Palaeont., 8 (2), p. 15, pl. 35, figs. 7-13, 1894.

Spirifer (Delthyris) perlamellosus Hall: A. W. Graban and H. W. Shimer, North American Index Fossils, 1, p. 320, text fig. 407 (p. 321), 1909.

Cyrtinopsis perlamellosus (Hall): J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 482, pl. 44, figs. 9, 10, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 42, pl. 6, figs. 6, 7, 1942.

M.U.G.D. No. 1722. HYPOTYPE, external mould of dorsal valve, figured by Gill, loc. cit., fig. 6, 1942.

M.U.G.D. No. 1723. HYPOTYPE, internal cast of ventral valve, figured by Gill, loc. cit., fig. 7, 1942.

Lower Devonian (Yeringian).

Hull Road, Mooroolbark, Victoria. E. D. Gill's Locality No. 13 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252 et seq., 1940).

Pres. Rev. E. D. Gill, 24.5.41.

Eospirifer densilineata (Chapman, 1908).

Spirifer perlamellosus J. Hall variety *densilineata* F. Chapman, Proc. Roy. Soc. Vic., n.s., 21 (1), p. 223, pl. 4, figs. 1, 2; pl. 5, August, 1908.

Eospirifer densilineata (Chapman): E. D. Gill, *ibid.*, 54 (1), p. 43, pl. 4, fig. 2, 1942.

M.U.G.D. No. 1715. HYPOTYPE, figured by Gill, loc. cit., 1942.

Lower Devonian (Yeringian).

Cemetery Hill Road, Whittlesea, Victoria (type locality). J. T. Jutson's Locality VII. (Proc. Roy. Soc. Vic., n.s., 21 (1), p. 213, pl. 3, 1908).

Pres. Rev. E. D. Gill, 24.5.41.

Fascicostella gervillei (Defrance, 1827).

Strophomenes gervillei M. J. L. Defrance, Dict. Sci. nat., 32, 51, p. 152, 1827.

Orthis gervillei Defrance: J. Barrande, Haidinger, Naturwiss. Abh. II, 1 Abth., p. 48, pl. 19, fig. 10, 1848. J. Barrande, Syst. sil. Bohême, 5, pl. 58, figs. 10*a-e*; pl. 60, fig. II, 1A, 2*c*, 3*a*, 4*e*; pl. 126, fig. II, 3*a*, *b*, 4*c*, 1879. C. Barrois, Mém. Soc. Géol. Nord. 2 (1), p. 237, pl. 9, fig. 1, 1882. D. P. Oehlert. Ann. Sci. géol., 19, p. 44, pl. 4, figs. 45-55, 1886. P. Assmann, Jahrb. K. preuss. geol. Landesanst., 31 (1), p. 161, pl. 10, fig. 3, 1910. F. Herrmann, *ibid.*, 33 (1), p. 349, pl. 21, figs. 4, 5, 1912. T. Hüffner, *ibid.*, 37 (1), p. 291. W. Paeckelmann, Abh. preuss. geol. Landesanst. N. F. 98, p. 116, 1925. R. Kozlowski, Palaeont. Polonica, 1, p. 70, pl. 1, fig. 32, 1929.

Dalmanella gervillei Defrance: W. Paeckelmann and H. Sieverts, Abh. preuss. geol. Landesanst. N.F. 142, p. 31, 1932.

Fascicostella gervillei Defrance: C. Schuchert and G. A. Cooper, Amer. Journ. Sci., [5] 22, p. 246, 1931. C. Schuchert and G. A. Cooper, Mem. Peabody Mus. Nat. Hist., 4, p. 129, pl. 92, figs. 12, 15, 1932. J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 466, pl. 41, figs. 4-6, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 37, pl. 6, figs. 3-5, 1942.

M.U.G.D. No. 1728. Hypotype, internal cast of ventral valve, figured by Gill, loc. cit., fig. 3, 1942.

M.U.G.D. No. 1729. Hypotype, internal cast of ventral valve, figured by Gill, loc. cit., fig. 4, 1942.

M.U.G.D. No. 1730. Hypotype, internal cast of dorsal valve, figured by Gill, loc. cit., fig. 5, 1942.

Lower Devonian (Yeringian).

Melbourne Hill, Lilydale, Victoria. E. D. Gill's Locality No. 7 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252, 259, 1940).

Pres. Rev. E. D. Gill, 24.5.41.

Hipparionyx minor Clarke, 1909.

Hipparionyx minor J. M. Clarke, Mem. New York State Mus., 9 (2), p. 124, pl. 31, figs. 16-20, 1909. J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 472, pl. 42, figs. 1-6, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 39, pl. 5, figs. 1, 10; pl. 6, fig. 2, 1942.

M.U.G.D. No. 1731. Hypotype, internal cast of ventral valve, figured by Gill, loc. cit., fig. 1, 1942.

M.U.G.D. No. 1732. Hypotype, external mould of ventral valve, counterpart of No 1731, figured by Gill, loc. cit., fig. 10, 1942.

Lower Devonian (Yeringian).

Hull Road, Mooroolbark, Victoria. E. D. Gill's Locality No. 13 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252 et seq., 1940).

Pres. Rev. E. D. Gill, 24.5.41.

Leptaena rhomboidalis (Wilckens, 1769).

Conchita rhomboidalis C. F. Wilckens, Nachr. Selt. Verst., p. 77, pl. 8, figs. 43, 44, 1769.

Strophomena rhomboidalis Wilckens sp.: J. Barrande, Syst. sil. Bohême, 5, p. 197, pl. 41, figs. 25*a-c*, 30*a*, *b*, 1879.

Leptaena rhomboidalis (Wilckens): J. Hall and J. M. Clarke, Nat. Hist. New York, pt. 6, Palaeont., 8 (1), pl. 8, figs. 20-27, 1892. A. W. Grabau and H. W. Shimer, North American Index Fossils, 1, p. 226, text-fig. 273*b*, 1909.

Leptaena (Leptagonia) rhomboidalis (Wilckens): F. McCoy, Prodromus Palaeont. Vic. Decade 5, p. 19, pl. 46, fig. 1, 1877.

[?] *Leptaena rhomboidalis* Wilckens sp.: F. Chapman, Proc. Roy. Soc. Vic., n.s., 26 (1), pp. 101, 102, pl. 10, fig. 3 (*non* p. 103, pl. 10, figs. 4-7), 1913.

Leptaena rhomboidalis (Wilckens): E. D. Gill, *ibid.*, 54 (1), p. 40, pl. 5, figs. 5, 8, 1942.

M.U.G.D. No. 1718. Hypotype, internal mould of dorsal valve, figured by Gill, loc. cit., fig. 3, 1942.

M.U.G.D. No. 1719. HYPOTYPE, external cast, counterpart of No. 1718, figured by Gill, loc. cit., fig. 8, 1942.

Lower Devonian (Yeringian).

Hull Road, Mooroolbark, Victoria. E. D. Gill's Locality No. 13 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252 et seq., 1940).

Pres. Rev. E. D. Gill, 24.5.41.

Nucleospira cf. **marginata** Maurer, 1886.

Nucleospira marginata F. Maurer, Die Fauna des rechtsrheinischen Unterdevon, Darmstadt, p. 19, 1886. L. Beushausen, Jahrb. K. preuss. geol. Landesanst., 17, p. 289, pl. 5, figs. 8-12, 1897.

Nucleospira cf. *marginata* Maurer: J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 481, pl. 94, figs. 6-8, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 43, pl. 4, fig. 5; pl. 5, fig. 6, 1942.

M.U.G.D. No. 1726. HYPOTYPE, internal cast of ventral valve, figured by Gill, loc. cit., pl. 4, fig. 5, 1942.

M.U.G.D. No. 1727. HYPOTYPE, internal cast of ventral valve, figured by Gill, loc. cit., pl. 5, fig. 6, 1942.

Lower Devonian (Yeringian).

Hull Road, Mooroolbark, Victoria. E. D. Gill's Locality No. 13 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252 et. seq., 1940).

Pres. Rev. E. D. Gill, 24.5.41.

Schizophoria provulvaria (Maurer, 1893).

Orthis provulvaria F. Maurer, Neues Jahrb. f. Min., 1, p. 7, pl. 3, figs. 1-4, 1893.

Schizophoria provulvaria (Maurer): F. Drevermann, Palaeontographica, 1, p. 267, pl. 30, figs. 29, 30, 1904. C. Schuchert and G. A. Cooper, Mem. Peabody Mus. Nat. Hist., 4 (1), pl. 23, fig. 11, 1932. F. Maillieux, Mem. Mus. roy. Hist. nat. Belg., 23, p. 53, 1936. J. Shirley, Quart. Journ. Geol. Soc. Lond., 94 (4), p. 465, pl. 40, figs. 10-13, 1938. E. D. Gill, Proc. Roy. Soc. Vic., n.s., 54 (1), p. 65, pl. 6, fig. 1, 1942.

M.U.G.D. No. 1733. HYPOTYPE, internal cast of ventral valve, figured by Gill, loc. cit., 1942.

Lower Devonian (Yeringian).

Hull Road, Mooroolbark, Victoria. E. D. Gill's Locality No. 13 (Proc. Roy. Soc. Vic., n.s., 52 (2), pp. 252 et. seq., 1940).

Pres. Rev. E. D. Gill, 24.5.41.

(?) **Siphonotreta lancefieldiensis** Sherrard, 1930.

(?) *Siphonotreta lancefieldiensis* K. Sherrard, Proc. Roy. Soc. Vic., n.s., 42 (2), p. 137, pl. 11, fig. 4, 13th March, 1930.

M.U.G.D. No. 995. HOLOTYPE, figured by Sherrard, loc. cit., 1930.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Coll. Sept., 1923 and pres. Mrs. K. Sherrard, 12.12.29.

Spirifer perlamellosus J. Hall, 1857.

See *Cyrtinopsis perlamellosus* (J. Hall, 1857).

Spirifer perlamellosus J. Hall var. **densilineata** Chapman, 1908.

See *Eospirifer densilineata* (Chapman, 1908).

Stropheodonta bipartita (Chapman, 1913).

Chonetes bipartita F. Chapman, Proc. Roy. Soc. Vic., n.s., 26 (1), p. 104, pl. 10, figs. 8-10, September, 1913.

Stropheodonta bipartita (Chapman): E. D. Gill, *ibid.*, 54 (1), p. 41, pl. 5, figs. 7, 9; pl. 6, fig. 10, 1942.

M.U.G.D. No. 1724. Hypotype, external moulds of both valves, figured by Gill, loc. cit., pl. 5, fig. 9; pl. 6, fig. 10, 1942.

M.U.G.D. No. 1725. Hypotype, internal casts of both valves, counterpart of No. 1724, figured by Gill, loc. cit., pl. 5, fig. 7, 1942.

Lower Devonian (Yeringian).

Yellingbo, Victoria. " . . . a low cutting on the road running west from the picnic ground beside Woori Yallock Creek, about a quarter of a mile from the creek" (Gill, loc. cit., p. 26, 1942).

Pres. Rev. E. D. Gill, 24.5.41.

PELECYPODA.

Antigona (Proxichione) cognata (Pritchard, 1903).

See *Chione cognata* Pritchard, 1903.

Antigona (Proxichione) etheridgei (Pritchard, 1903).

See *Chione etheridgei* Pritchard, 1903.

Arca capulopsis Pritchard, 1901.

Arca capulopsis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 23, pl. 2, figs. 1, 2, August, 1901.

M.U.G.D. No. 1773. Holotype, left valve, figured by Pritchard, loc. cit., 1901.

Miocene (Balcombian).

Orphanage Hill, Fyansford, near Geelong, Victoria.

Coll. T. S. Hall. Purchased from Dr. G. B. Pritchard, 11.10.39.

Aulacomya mooraboolensis (Pritchard, 1903).

See *Mytilus mooraboolensis* Pritchard, 1903.

Cardita excrescens Pritchard, 1903:—**Venericardia excrescens** (Pritchard, 1903).

Cardita excrescens G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 98, pl. 12, figs. 2, 3, February, 1903.

M.U.G.D. No. 1753. Holotype, left valve, figured by Pritchard, loc. cit., 1903.

Miocene (Balcombian).

Shores of Lake Bullen Merri, near Camperdown, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Cardita maudensis Pritchard, 1895:—**Venericardia maudensis** (Pritchard, 1895).

Cardita maudensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 7, p. 229, pl. 12, figs. 6, 7, January, 1895. G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 360, 1897.

M.U.G.D. No. 1745. Syntype, right valve, figured by Pritchard, loc. cit., fig. 6, 1895.

M.U.G.D. No. 1746. Syntype, left valve, figured by Pritchard, loc. cit., fig. 7, 1895.

Miocene (Janjukian?).

"Lower Eocene calcareous sands, Moorabool Valley near Maude" (Pritchard, 1895) = Lower beds, Maude, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Carditella regularis Pritchard, 1901.

Carditella regularis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 28, pl. 2, fig. 5, August, 1901.

M.U.G.D. No. 1775. Holotype, right valve, figured by Pritchard, loc. cit., 1901.

Grice's Creek, between Frankston and Mornington, Port Phillip, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Chione cognata Pritchard, 1903:—**Antigona (Proxichione) cognata** (Pritchard, 1903).

Chione cognata G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 101, pl. 12, fig. 5, February, 1903.

M.U.G.D. No. 1755. Holotype, left valve, figured by Pritchard, loc. cit., 1903.

Lower Pliocene (Kalimnan).

Grange Burn, below Forsyth's, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Chione etheridgei Pritchard, 1903:—**Antigona (Proxichione) etheridgei** (Pritchard, 1903).

Chione etheridgei G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 99, pl. 12, fig. 1, February, 1903.

M.U.G.D. No. 1752. Holotype, left valve, figured by Pritchard, loc. cit., 1903.

Miocene (Janjukian).

"Lower beds of the Spring Creek series or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 100, 1903) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Chione halli Pritchard, 1895.

Chione halli G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 7, p. 229, pl. 12, figs. 10-12, January, 1895. Not *Chione hallii* R. Tate, Trans. Roy. Soc. S. Aust., 24 (2), p. 107, pl. 2, fig. 5, 1901 (=*Chione roberti* G. B. Pritchard, nom. mut., Vic. Naturalist, 23 (6), p. 117, 4th October, 1906.)

M.U.G.D. No. 1749. Syntype, right valve, figured by Pritchard, loc. cit., fig. 10, 1895.

M.U.G.D. No. 1750. Syntype, left valve, figured by Pritchard, loc. cit., fig. 11, 1895.

M.U.G.D. No. 1751. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 12, 1895.

Miocene (Janjukian).

"Lower Eocene sands and clays of Spring Creek, 14 miles south of Geelong" (Pritchard, 1895) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Chlamys asperrimus asperrimus (Lamarck, 1819).

Pecten asperrimus J. P. B. A. Lamarck, Hist. Nat. Anim. s. Vert., 11, p. 174, 1819. B. Delessert, Rec. Coq. décr. par Lamarck dans son Hist. Nat. Anim. s. Vert. et non encore figurées, pl. 15, figs. 1*a*, 1*b*. 1841.

Chlamys apserrimus asperrimus (Lamarck, 1819): J. H. Gatliff and F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 42 (2), p. 73, pl. 2, figs. 1, 2; pl. 3, fig. 5; pl. 4, fig. 10, March, 1930.

M.U.G.D. No. 989. HYPOTYPE, figured by Gatliff and Singleton, loc. cit., pl. 2, fig. 1; pl. 4, fig. 11, 1930.

M.U.G.D. No. 990. HYPOTYPE, counterpart of No. 989, figured by Gatliff and Singleton, loc. cit., pl. 3, fig. 5, 1930

M.U.G.D. No. 991. HYPOTYPE, figured by Gatliff and Singleton, loc. cit., pl. 2, fig. 2, 1930.

M.U.G.D. No. 992. COUNTERPART OF HYPOTYPE No. 991.

Recent.

Westernport, Victoria (dredged).

Pres. J. H. Gatliff, 8.8.29.

Crassatellites camurus Pritchard, 1903:—Eucrassatella camura (Pritchard, 1903).

Crassatellites camurus G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 96, pl. 14, figs. 5-9, February, 1903.

M.U.G.D. No. 1761. SYNTYPE, left valve, figured by Pritchard, loc. cit., fig. 5, 1903.

M.U.G.D. No. 1762. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 6, 1903.

Lower Pliocene (Kalimnan).

Grange Burn, between Forsyth's and Henty's, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

M.U.G.D. No. 1763. SYNTYPE, juvenile left valve, figured by Pritchard, loc. cit., fig. 7, 1903.

M.U.G.D. No. 1764. SYNTYPE, juvenile right valve, figured by Pritchard, loc. cit., fig. 8, 1903.

M.U.G.D. No. 1765. SYNTYPE, juvenile right valve, figured by Pritchard, loc. cit., fig. 9, 1903.

M.U.G.D. No. 1766. SYNTYPE, juvenile left valve, unfigured.

Lower Pliocene (Kalimnan).

"Muddy Creek, near the State School" (Pritchard, loc. cit., p. 97, 1903) = MacDonald's, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

The above shells (Nos. 1761-6) were in a box with a label in Pritchard's handwriting, "Crassatellites camarus [*sic*] Pritchard. *Types*. Miocene. Grange Burn and Muddy Creek, W. Vic." They have been allocated to the above localities upon their mode of preservation.

Crassatellites kingicoloides Pritchard, 1903:—**Eucrassatella kingicoloides** (Pritchard, 1903).

Crassatellites kingicoloides G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 94, pl. 13, figs. 1-3, February, 1903.

M.U.G.D. No. 1756. HOLOTYPE, paired valves, figured by Pritchard, loc. cit., 1903.

Lower Pliocene (Kalimnan).

Jimmy's Point [= Jemmy's Point], Kalimna, Gippsland Lakes, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Crassatellites maudensis Pritchard, 1903:—**Eucrassatella maudensis** (Pritchard, 1903).

Crassatellites maudensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 93, pl. 14, figs. 2, 3, February, 1903.

M.U.G.D. No. 1758. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 2, 1903.

M.U.G.D. No. 1759. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 3, 1903.

Miocene (Janjukian).

"Lower and Middle beds of the Spring Creek series, or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 94, 1903) = Bird Rock cliffs, near Spring Creek, Torquay, Victoria. The inner lid of box bears "Spring Creek" only.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Cucullaea corioensis praelonga Singleton, 1932:—**Cucullaea praelonga** (Singleton, 1932).

Cucullaea corioensis F. McCoy, Prodromus Palaeont. Vic., decade 3, pl. 27, figs. 3(?), 5*a* (*non* 4, 5), 1876.

Cucullaea corioensis praelonga F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 44 (2), p. 303, pl. 26, figs. 20*a*, *b*, 20th April, 1932.

M.U.G.D. No. 1320. HOLOTYPE, right valve, figured by Singleton, loc. cit., 1932.

Lower Pliocene (Kalimnan).

"Forsyth's," Grange Burn, near Hamilton, Victoria.

Coll. H. S. Summers. Presented by F. A. Singleton, 29.2.32. It was formerly No. 5 in F. A. Singleton's private collection.

Cucullaea praelonga (Singleton, 1932).

See *Cucullaea corioensis praelonga* Singleton, 1932.

Cucullaea (Cucullona) psephea Singleton, 1943.

Cucullaea (Cucullona) psephea F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 270, pl. 13, figs. 7*a*, *b*; 8*a*, *b*, October, 1943.

M.U.G.D. No. 1869. HOLOTYPE, right valve, figured by Singleton, loc. cit., fig. 7*a*, *b*, 1943.

M.U.G.D. No. 1870. PARATYPE, right valve, figured by Singleton, loc. cit., fig. 8*a*, *b*, 1943.

Eocene.

Second point north-west of Pebble Point, coastal cliffs 2½ miles south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

Dosinia densilineata Pritchard, 1896.

Dosinia densilineata G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 135, pl. 4, figs. 5-7, April, 1896.

M.U.G.D. No. 1738. Syntype, left valve, figured by Pritchard, loc. cit., fig. 5, 1896.

M.U.G.D. No. 1739. Syntype, paired valves, figured by Pritchard, loc. cit., fig. 6, 1896.

M.U.G.D. No. 1740. Syntype, right valve, figured by Pritchard, loc. cit., fig. 7, 1896.

Miocene (Janjukian).

"Lower Eocene sandy beds of Spring Creek, near Geelong" (Pritchard, loc. cit., p. 137, 1896) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Eotrigonia intersitans (Tate, 1896).

See *Trigonia tatei* Pritchard, 1895.

Eotrigonia lutosa (Pritchard, 1903).

See *Trigonia semiundulata* Jenkins var. *lutosa* Pritchard, 1903.

Eotrigonia semiundulata (Jenkins, 1865).

See *Trigonia semiundulata* Jenkins, 1895.

Eotrigonia semiundulata granosa (Pritchard, 1903).

See *Trigonia semiundulata* Jenkins var. *granosa* Pritchard, 1903.

Eucrassatella camura (Pritchard, 1903).

See *Crassatellites camurus* Pritchard, 1903.

Eucrassatella kingicoloides (Pritchard, 1903).

See *Crassatellites kingicoloides* Pritchard, 1903.

Eucrassatella maudensis (Pritchard, 1903).

See *Crassatellites maudensis* Pritchard, 1903.

Glycimeris halli Pritchard, 1903:—**Glycymeris halli** (Pritchard, 1903).

Glycimeris halli G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 89, pl. 15, figs. 1, 2, 8, February, 1903.

Glycymeris halli, Pritchard: F. Chapman and F. A. Singleton, *ibid.*, 37 (1), p. 40, pl. 3, fig. 25; pl. 4, fig. 15, 1925.

M.U.G.D. No. 1783. Holotype, left valve, figured by Pritchard, loc. cit., figs. 1, 2, 1903.

M.U.G.D. No. 1784. PARATYPE, juvenile left valve, figured by Pritchard, loc. cit., fig. 8, 1903.

Lower Pliocene (Kalimnan).

Upper beds, Muddy Creek, near Hamilton, Victoria.

While the above type material is marked as from "M.C." = Muddy Creek, this term is commonly used to include the upper beds at the adjacent stream, Grange Burn. Pritchard (loc. cit., p. 91, 1903) includes as localities "Grange Burn, between Forsyth's and Henty's, from the clays and sands of the upper series; Muddy Creek, from the upper beds below the State School." This latter locality is commonly known as MacDonald's, Muddy Creek. The paratype is probably, on its mode of preservation, from near Forsyth's, Grange Burn: whether the holotype is from Forsyth's or MacDonald's is uncertain.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Glycimeris halli Pritchard var. **intermedius** Pritchard, 1903:—
Glycymeris halli mistio (Finlay, 1927).

Glycimeris halli Pritchard, variety *intermedius* G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 90, pl. 14, figs. 10, 11, February, 1903. Not *Pectunculus intermedius* Broderip, Proc. Zool. Soc. Lond., pt. 2, p. 126, 1832.

Glycymeris halli var. *intermedia* Pritchard: F. Chapman and F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 37 (1), p. 41, 1925.

Glycimeris halli mistio H. J. Finlay, nom. nov., Trans. N.Z. Inst., 57, p. 524, 1927.

M.U.G.D. No. 1785. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 10, 1903.

M.U.G.D. No. 1786. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 11, 1903.

Lower Pliocene (Kalimnan).

Upper beds, Muddy Creek, near Hamilton, Victoria.

The same remarks apply to this as to the preceding, but the coloration of the specimens suggests that they are from MacDonald's, Muddy Creek.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Glycimeris halli Pritchard var. **paucicostatus** Pritchard, 1903:—
Glycymeris halli paucicostata (Pritchard, 1903).

Glycimeris halli Pritchard, variety *paucicostatus* G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 90, pl. 14, fig. 12; pl. 15, fig. 9, February, 1903.

Glycymeris halli var. *paucicostata* Pritchard: F. Chapman and F. A. Singleton, *ibid.*, 37 (1), p. 42, 1925.

M.U.G.D. No. 1787. SYNTYPE, left valve, figured by Pritchard, loc. cit., pl. 14, fig. 12, 1903.

M.U.G.D. No. 1788. SYNTYPE, left (?) valve, figured by Pritchard, loc. cit., pl. 15, fig. 9, 1903.

Lower Pliocene (Kalimnan).

"Sandy clays of Jimmy's Point, Gippsland" (Pritchard, loc. cit., p. 91, 1903) = Jemmy's Point, Kalimna, Gippsland Lakes, Victoria.

Glycymeris (Grandaxinaea) granti Singleton, 1932.

Glycymeris (Grandaxinaea) granti F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 44 (2), p. 294, pl. 24, figs. 10*a*, 10*b*, 11, April, 1932.

M.U.G.D. No. 1315. HOLOTYPE, left valve, figured by Singleton, loc. cit., figs. 10*a*, 10*b*, 1932.

M.U.G.D. No. 1316. Paratype, right valve, figured by Singleton, loc. cit., fig. 11, 1932.

Miocene (Balcombian).

Lower Beds, Muddy Creek, near Hamilton, Victoria.

Pres. F. H. McK. Grant, 24.6.31.

Glycymeris halli (Pritchard, 1903).

See *Glycimeris halli* Pritchard, 1903.

Glycymeris halli mistio (Finlay, 1927).

See *Glycimeris halli* Pritchard var. *intermedius* Pritchard, 1903.

Glycymeris halli paucicostata (Pritchard, 1903).

See *Glycimeris halli* Pritchard var. *paucicostatus* Pritchard, 1903.

Glycymeris (Veletuceta) pseudaustralis Singleton, 1941.

Glycymeris (Veletuceta) pseudaustralis F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 53 (2), p. 425, pl. 20, figs. 4, 5. July, 1941.

M.U.G.D. No. 1674. Holotype, right valve, figured by Singleton, loc. cit., fig. 4, 1941.

M.U.G.D. No. 1675. Paratype, right valve, figured by Singleton, loc. cit., fig. 5, 1941.

Upper Pliocene (Werrikooian).

Glenelg River at "Roscoe's", Parish of Killara, Victoria. (Holotype No. 1674.)

Caldwell's Cliff, Glenelg River, Parish of Werrikoo, Victoria. (Paratype No. 1675.)

Coll and pres. F. A. Singleton, 12.12.40.

Lahillia australica Singleton, 1943.

Lahillia australica F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 273, pl. 12, figs. 3-5. October, 1943.

M.U.G.D. No. 1865. Holotype, left valve, figured by Singleton, loc. cit., fig. 5, 1943.

Eocene.

Second point north-west of Pebble Point, coastal cliffs 2½ miles south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

M.U.G.D. No. 1866. Paratype, right valve, figured by Singleton, loc. cit., fig. 3, 1943.

M.U.G.D. No. 1867. Paratype, left valve, figured by Singleton, loc. cit., fig. 4, 1943.

Eocene.

East side of Pebble Point, coastal cliffs 2½ miles south-east of Princetown, Victoria.

Coll. Oct., 1915, and pres. W. J. Parr, Dec., 1942.

Leda acuticauda Pritchard, 1901:—**Nuculana acuticauda** (Pritchard, 1901).

Leda acuticauda G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 27, pl. 3, figs. 4, 4*a*, August, 1901.

M.U.G.D. No. 1781. Holotype, paired valves, figured (right valve) by Pritchard, loc. cit., 1901.

M.U.G.D. No. 1782. Paratype, right valve, unfigured.

Miocene (Balcombian).

Grice's Creek, between Frankston and Mornington, Port Phillip, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Leda fontinalis Pritchard, 1901:—**Nuculana fontinalis** (Pritchard, 1901).

Leda fontinalis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 28, pl. 3, figs. 3, 3*a*, August, 1901.

M.U.G.D. No. 1779. Holotype, paired valves, figured (left valve) by Pritchard, loc. cit., 1901. Now separated into left (1779A) and right (1779B) valves.

M.U.G.D. No. 1780. Paratype, left valve, unfigured.

"Lower beds of the Spring Creek or Bird Rock Bluff section, near Geelong" (Pritchard, loc. cit., p. 28, 1901) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Limopsis chapmani Singleton, 1932.

"*Limopsis aurita* (Brocchi)": F. McCoy, Prodromus Palaeont. Vic., decade 2, p. 23, pl. 19, figs. 5, 6, 6*a*, *b*, 7, 1875. R. Tate, Pap. Roy. Soc. Tas. for 1884, p. 212, 1885. R. Tate, Trans. Roy. Soc. S. Aust., 8, p. 134, 1886. R. M. Johnston, Geology of Tasmania, pl. 32, fig. 7, 1888. Not *Arca aurita* Brocchi, Conchiologia Fossile Subapennina, p. 485, pl. 11, figs. 9*a*, *b*, 1814.

"*Limopsis insolita* (G. B. Sowerby)": R. Tate, Trans. Roy. Soc. S. Aust., 8, p. 134, 1886. G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 344, 1897. F. Chapman, Proc. Roy. Soc. Vic., n.s., 23 (2), p. 425, pl. 84, fig. 5; pl. 85, fig. 11, 1911. Not *Trigonocoelia insolita* G. B. Sowerby, in C. Darwin, Geol. Obs. S. Amer., p. 252 (2nd ed., p. 608, 1876), pl. 2, figs. 20, 21, 1846.

Limopsis chapmani F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 44 (2), p. 296, pl. 24, figs. 12-14; pl. 25, figs. 16*a-c*, 20th April, 1932.

M.U.G.D. No. 1317. Holotype, right valve of pair, figured by Singleton, loc. cit., figs. 16*a-c*, 1932.

M.U.G.D. No. 1318. Paratype, right valve, figured by Singleton, loc. cit., fig. 12, 1932.

M.U.G.D. No. 1319. Paratype, right valve, figured by Singleton, loc. cit., fig. 13, 1932.

Miocene (Janjukian).

Lower beds, Bird Rock Cliffs, near Spring Creek, Torquay, Victoria.

Coll. and pres. F. A. Singleton, 29.2.32.

Limopsis morningtonensis Pritchard, 1901.

Limopsis morningtonensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 24, pl. 2, figs. 6, 6*a*, August, 1901. F. Chapman, *ibid.*, 23 (2), p. 420, pl. 83, fig. 1; pl. 85, fig. 7, 1911.

M.U.G.D. No. 1778. Holotype, left valve, figured by Pritchard, loc. cit., 1901.

Miocene (Balcombian).

"Eocene clays of Gellibrand River, coast section below Curdie's Steps" (Pritchard, loc. cit., p. 24, 1903), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Limopsis sp.

Limopsis sp. nov. (?), F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 271, pl. 12, figs. 2*a*, *b*, October, 1943.

M.U.G.D. No. 1872. FIGURED SPECIMEN, left valve, figured by Singleton, loc. cit., 1943.

Eocene.

Second point north-west of Pebble Point, coastal cliffs 2½ miles south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

Lithophagus latecaudatus Pritchard, 1903:—**Modiolus latecaudatus** (Pritchard, 1903).

Lithophagus latecaudatus G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 88, pl. 14, fig. 4, February, 1903.

M.U.G.D. No. 1760. HOLOTYPE, left valve, figured by Pritchard, loc. cit., 1903.

Miocene (Janjukian).

"Lower beds of the Spring Creek series, or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 88, 1903) = Lower Beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Dr. Pritchard states (personal communication) the type to have come from near the "ledge", a well-known locality near the base of the cliffs just south-west of Bird Rock. The species is, however, not uncommon in the lowest bed, bluish clay, exposed in the centre of the half dome at this locality, and it is probable that the type is from this bed.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Lucina gunyoungensis Pritchard, 1903.

Lucina gunyoungensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 98, pl. 14, fig. 13, February, 1903.

M.U.G.D. No. 1767. HOLOTYPE, right valve, figured by Pritchard, loc. cit., 1903.

Miocene (Balcombian).

Grey clays of Grice's Creek = Gunyoung Creek, Mornington.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Lucina (Prolucina) mitchelli Pritchard, 1913:—**Prolucina mitchelli** (Pritchard, 1913).

Lucina (Prolucina) mitchelli G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 25 (2), p. 363, pl. 29, figs. 1-3, March, 1913.

M.U.G.D. No. 1668. HOLOTYPE, figured by Pritchard, loc. cit., 1913.

Lower Devonian (Yeringian).

"Cave Hill Quarries, Lilydale. Silurian limestone fauna" (Pritchard, loc. cit., p. 364, 1913) = Mitchell's quarry, Cave Hill, near Lilydale, Victoria.

Collected by S. R. Mitchell. Purchased from Dr. G. B. Pritchard, 11.10.39.

Modiola praerupta Pritchard, 1901:—**Modiolus praeruptus** (Pritchard, 1901).

Modiola praerupta G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 25, pl. 2, figs. 3, 4, August, 1901.

M.U.G.D. No. 1774. HOLOTYPE, right valve, figured by Pritchard, loc. cit., 1901.

Miocene (Balcombian).

"Eocene Septarian Limestones, near the Old Cement Works, Balcombe's Bay, Mornington" (Pritchard, loc. cit., p. 26, 1901), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Modiola pueblensis Pritchard, 1901:—**Modiolus pueblensis** (Pritchard, 1901).

Modiola pueblensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 26, pl. 3, fig. 1, August, 1901.

M.U.G.D. No. 1777. HOLOTYPE, left valve, figured by Pritchard, loc. cit., 1901.

Miocene (Janjukian).

"Lower beds of the Spring Creek or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 27, 1901) - Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Modiolus praeruptus Pritchard, 1901.

See *Modiola praerupta* (Pritchard, 1901).

Modiolus pueblensis (Pritchard, 1901).

See *Modiola pueblensis* Pritchard, 1901.

Modiolaria balcombei Pritchard, 1901:—**Musculus balcombei** (Pritchard, 1901).

Modiolaria balcombei G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 29, pl. 3, fig. 2, August, 1901.

M.U.G.D. No. 1776. HOLOTYPE, figured by Pritchard, loc. cit., 1901.

Miocene (Balcombian).

"Eocene clays from the Old Cement Works, Balcombe's Bay, Mornington" (Pritchard, loc. cit., p. 30, 1901), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Modiolus latecaudatus (Pritchard, 1903).

See *Lithophagus latecaudatus* Pritchard, 1903.

Musculus balcombei (Pritchard, 1901).

See *Modiolaria balcombei* Pritchard, 1901.

Myochama trapezia Pritchard, 1895.

Myochama trapezia G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 7, p. 227, pl. 12, figs. 8, 9, January, 1895.

M.U.G.D. No. 1747. SYNTYPE, left valve, figured by Pritchard, loc. cit., fig. 8, 1895.

M.U.G.D. No. 1748. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 9, 1895.

Miocene (Balcombian).

Blue clays, Curlewis, Bellarine Peninsula, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Mytilicardia kalimnae Pritchard, 1903.

Mytilicardia kalimnae G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 97, pl. 12, fig. 4, February, 1903.

M.U.G.D. No. 1754. Holotype, left valve, figured by Pritchard, loc. cit., 1903.

Lower Pliocene (Kalimnan).

Jimmy's Point [= Jemmy's Point], Kalimna, Gippsland Lakes, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Mytilus mooraboolensis Pritchard, 1903:—**Aulacomya mooraboolensis** (Pritchard, 1903).

Mytilus mooraboolensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 88, pl. 14, fig. 1, February, 1903.

M.U.G.D. No. 1757. Holotype, right valve, figured by Pritchard, loc. cit., 1903.

Miocene (Janjukian).

"Lower beds of the Spring Creek series, or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 89, 1903) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Nucula (Ennucula) gricei Singleton, 1941.

"*Nucula tenisoni* Pritchard". F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 44 (2), p. 290, pl. 24, figs. 5*a*, 5*b*, April, 1932. Not *Nucula tenisoni* G. B. Pritchard, *ibid.*, 8, p. 128, April, 1896.

Nucula (Ennucula) gricei F. A. Singleton, *ibid.*, 53 (2), p. 423, pl. 20, figs. 1*a*, 1*b*, July, 1941.

M.U.G.D. No. 1311. Holotype, figured by Singleton, loc. cit., 1932 (as hypotype of *N. tenisoni*) and loc. cit., 1941.

Miocene (Balcombian).

Grice's Creek, between Frankston and Mornington, Victoria.

Coll and pres. F. A. Singleton, 29.2.32.

Nucula kalimnae Singleton, 1932:—**Nucula (Ennucula) kalimnae** Singleton, 1932.

"*Nucula tumida* Tenison-Woods": R. Tate, Trans. Roy. Soc. S. Aust., 8, p. 127, pl. 6, figs. 6*a*, 6*b*, May, 1886. Not *Nucula tumida* J. E. T. Woods, Pap. Proc. Roy. Soc. Tas. for 1876, p. 111, 1877.

Nucula kalimnae F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 44 (2), p. 292, pl. 24, figs. 7*a*, 7*b*, 8*a*, 8*b*, 9, April, 1932.

M.U.G.D. No. 1312. Holotype, figured by Singleton, loc. cit., figs. 7*a*, 7*b*, 1932.

Lower Pliocene (Kalimnan).

Jemmy's Point, Kalimna, Victoria.

Coll. and pres. F. A. Singleton, 29.2.32.

M.U.G.D. No. 1313. Paratype, figured by Singleton, loc. cit., figs. 8*a*, 8*b*, 1932.

M.U.G.D. No. 1314. Paratype, figured by Singleton, loc. cit., fig. 9, 1932.

Lower Pliocene (Kalimnan).

Upper beds, Muddy Creek, near Hamilton, Victoria.

Purchased from T. Worcester.

Nucula (Ennucula) kalimnae Singleton, 1932.

See *Nucula kalimnae* Singleton, 1932.

Nuculana acuticauda (Pritchard, 1901).

See *Leda acuticauda* Pritchard, 1901.

Nuculana fontinalis (Pritchard, 1901).

See *Leda fontinalis* Pritchard, 1901.

Nuculana paucigradata Singleton, 1943.

Nuculana paucigradata F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 268, pl. 12, figs. 1*a*, *b*, October, 1943.

M.U.G.D. No. 1868. Holotype, left valve, figured by Singleton, loc. cit., 1943.

Eocene.

Second point north-west of Pebble Point, coastal cliffs 2½ miles south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

Nuculana (Scaeoleda) killara Singleton, 1941.

Nuculana (Scaeoleda) killara F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 53 (2), p. 424, pl. 20, fig. 2, July, 1941.

M.U.G.D. No. 1673. Holotype, left valve, figured by Singleton, loc. cit., 1941.

Upper Pliocene (Werrikooian).

Glenelg River at "Roscoe's", Parish of Killara, Victoria.

Coll. 29.5.24, and pres. F. A. Singleton, 12.12.40.

Obs.—This specimen is missing. It was formerly No. 21 in F. A. Singleton's private collection.

Ostrea sinuata glenelgensis Singleton, 1941.

Ostrea sinuata glenelgensis F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 53 (2), p. 426, pl. 20, fig. 6, July, 1941.

M.U.G.D. No. 1676. Syntype, figured by Singleton, loc. cit., 1941.

M.U.G.D. No. 1677. Syntype, counterpart of No. 1676.

Upper Pliocene (Werrikooian).

Glenelg River, Allotment 16A, Parish of Werrikoo, Western Victoria.

Coll. 30.5.24, and pres. F. A. Singleton, 12.12.40.

Pecten asperrimus Lamarck, 1819.

See *Chlamys asperrimus asperrimus* (Lamarck, 1819).

Pinna cordata Pritchard, 1895.

Pinna cordata G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 7, p. 228, pl. 12, figs. 4, 5, January, 1895.

M.U.G.D. No. 1744. Holotype, paired valves, figured by Pritchard, loc. cit., 1895.

Miocene (Barwonian: probably Balcombian).

Sandy limestones, Barwon River, near its junction with the Native Hut Creek, Victoria.

Coll. J. Betheras. Purchased from Dr. G. B. Pritchard, 11.10.39.

Prolucina mitchelli (Pritchard, 1913).

See *Lucina (Prolucina) mitchelli* Pritchard, 1913.

Trigonia semiundulata Jenkins, 1865:—**Eotrigonia semiundulata** (Jenkins, 1865).

Trigonia subundulata M'Coy MS.: H. M. Jenkins, Quart. Journ. Sci., 2, p. 363, 1865 (*nomen nudum*).

Trigonia semiundulata M'Coy MS.: H. M. Jenkins, *ibid.*, pl. opp. p. 630, fig. 6, 1865.

Trigonia semiundulata F. M'Coy, Geol. Mag., 3, p. 481, 1866.

Trigonia semiundulata F. McCoy Prodromus Palaeont. Vic., decade 2, p. 22, pl. 19, figs. 4, 5, 1878.

Trigonia semiundulata McCoy: W. Bednall, Trans. Phil. Soc. Adelaide, for 1877-8, p. 81, 1878. R. Tate, Trans. Roy. Soc. S. Aust., 8, p. 145, 1886. R. M. Johnston, Geol. Tas., p. 235, pl. 29, fig. 5. 1888. R. Etheridge, jun., Rec. Geol. Surv. N.S. Wales, 3 (4), p 115, 1893.

Trigonia subundulata (M'Coy MS.) Jenkins: G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 352, 1897.

Trigonia semiundulata Jenkins: G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 91, pl. 15, figs. 3, 4, 1903. J. Marwick, Rept. Aust. Assoc. Adv. Sci., 16, p. 327, 1924.

Trigonia subundulata Jenkins: H. Suter, N.Z. Geol. Surv. Pal. Bull. 2, p. 39, pl. 4, fig. 5, 1914.

M.U.G.D. No. 1768. Hypotype, right valve, figured by Pritchard, loc. cit., fig. 3, 1903.

M.U.G.D. No. 1769. Hypotype, right valve, figured by Pritchard, loc. cit., fig. 4, 1903.

Miocene (Janjukian).

"Spring Creek series" (Pritchard, loc. cit., p. 103, 1903) = Lower Beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Trigonia semiundulata Jenkins var. **granosa** Pritchard, 1903:—**Eotrigonia semiundulata granosa** (Pritchard, 1903).

Trigonia semiundulata Jenkins, variety *granosa*, G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 92, pl. 15, fig. 5, February, 1903.

M.U.G.D. No. 1770. Holotype, right valve, figured by Pritchard, loc. cit., 1903.

Miocene (Janjukian).

"Lower beds of the Spring Creek series, or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 92, 1903) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Trigonia semiundulata Jenkins var. **lutosa** Pritchard, 1903:—**Eotrigonia lutosa** (Pritchard, 1903).

Trigonia semiundulata Jenkins, variety *lutosa* G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 15 (2), p. 92, pl. 15, figs. 6, 7, February, 1903.

M.U.G.D. No. 1771. Syntype, left valve, figured by Pritchard, loc. cit., fig. 6, 1903.

M.U.G.D. No. 1772. Syntype, left valve, figured by Pritchard, loc. cit., fig. 7, 1903.

Miocene (Balcombian).

Lower Beds of Muddy Creek, Western Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Trigonia tatei Pritchard, 1895:—**Eotrigonia intersitans** (Tate, 1896).

Trigonia tatei G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 7, p. 225, pl. 12, figs. 1-3, January, 1895. G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 353, 1897. Not *Trigonia tatei* E. Holub and M. Neumayr, Denkschr. d. Math. Naturw. Cl. d. K. Akad. d. Wiss. Wien, 44, p. 275, pl. 2, fig. 3, 1881.

Trigonia tatei Pritchard: G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 353, 1897.

Trigonia intersitans R. Tate, nom. mut., in R. Tate and J. Dennant, Trans. Roy. Soc. S. Aust., 20 (1), p. 146 and footnote, September, 1896.

M.U.G.D. No. 1741. SYNTYPE, left valve, figured by Pritchard, loc. cit., figs. 1, 3, 1895.

M.U.G.D. No. 1742. SYNTYPE, right valve, figured by Pritchard, loc. cit., fig. 2, 1895.

M.U.G.D. No. 1743. SYNTYPE, right valve, unfigured.

Miocene (Janjukian?).

"Lower Eocene calcareous sands, Moorabool Valley, near Maude" (Pritchard, loc. cit., p. 226, 1895) = Lower beds, Maude, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Venericardia excrescens (Pritchard, 1903).

See *Cardita excrescens* Pritchard, 1903.

Venericardia maudensis (Pritchard, 1895).

See *Cardita maudensis* Pritchard, 1895.

Verticordia excavata Pritchard, 1901.

Verticordia excavata G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 30, August, 1901.

M.U.G.D. No. 1799. HOLOTYPE, right valve, unfigured.

Miocene (Balcombian).

"Eocene clays from near the Old Cement Works, Balcombe's Bay, Mornington" (Pritchard, loc. cit., p. 30, 1901), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

SCAPHOPODA.

Dentalium (Fissidentalium) gracilicostatum Singleton, 1943.

Dentalium (Fissidentalium) gracilicostatum F. A. Singleton, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 275, pl. 12, figs. 6a, b; pl. 13, figs. 9a, b, October, 1943.

M.U.G.D. No. 1871. HOLOTYPE, figured by Singleton, loc. cit., 1943.

Eocene.

Bay between first and second points north-west of Pebble Point, coastal cliffs 2½ miles south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

GASTEROPODA.

Apiotoma bassi Pritchard, 1904.

Apiotoma bassi G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 328, pl. 19, fig. 11, September, 1904. H. J. Finlay, Trans. N.Z. Inst., 56 (1), p. 252, 1926. A. W. B. Powell, Bull. Auck. Inst. Mus., 2, p. 65, 1942. A. W. B. Powell, Rec. Auck. Inst. Mus., 3 (1), p. 20, 1944.

M.U.G.D. No. 1825. HOLOTYPE, figured by Pritchard, loc. cit., 1904.

Miocene (Janjukian).

"Clays of the Cape Otway section, near Point Flinders" (Pritchard, loc. cit., p. 329, 1904), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Apiotoma granti (Pritchard, 1904).

See *Pleurotoma granti* Pritchard, 1904.

Astele millegranosa Pritchard, 1904.

Astele millegranosa G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 332, pl. 19, figs. 7, 8, September, 1904.

M.U.G.D. No. 1828. HOLOTYPE, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

Lower beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Astralium (Imperator) johnstoni Pritchard, 1896:—**Imperator johnstoni** (Pritchard, 1896).

Astralium (Imperator) johnstoni G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 116, April, 1896.

M.U.G.D. No. 1810. SYNTYPE, internal cast in two pieces (1810A and 1810B) which fit together, unfigured.

Miocene (Balcombian?)

"Royal Park" (Pritchard, loc. cit., p. 118, 1896) = Lower beds, Royal Park railway cutting, between Flemington and Royal Park stations, near Melbourne, Victoria.

Collected by Rev. M. Ramage (?). Purchased from Dr. G. B. Pritchard, 11.10.39.

M.U.G.D. No. 1811. SYNTYPE, external mould, unfigured.

M.U.G.D. No. 1812. SYNTYPE, internal cast (not a counterpart of preceding), unfigured.

Miocene (Balcombian?).

"Eocene ferruginous beds of Keilor" (Pritchard, loc. cit., p. 118, 1896) = Green Gully, near Keilor, Victoria.

Collected by T. S. Hart (?). Purchased from Dr. G. B. Pritchard, 11.10.39.

Obs.—In the synonymy cited by Pritchard is included *Imperator hudsoniana* R.M. Johnston, Geology of Tasmania, pl. 29, figs. 12, 12*a*, 1888, which would seem to be the valid name for the present species. Since Pritchard (loc. cit.) regards their identity as extremely doubtful and the two come from different geological horizons, Pritchard's name has been allowed to stand.

Aulica weldii (T. Woods, 1876).

See *Voluta weldii* T. Woods, 1876.

Aulica weldii angustior (Pritchard, 1913).

See *Voluta weldii* var. *angustior* Pritchard, 1913.

Aulica weldii intermedia (Pritchard, 1913).

See *Voluta weldii* var. *intermedia* Pritchard, 1913.

Austrolithes bulbodes (Tate, 1888).

See *Clavella bulbodes* (Tate, 1888).

Austrolithes platystropha (Pritchard, 1904).

See *Clavella platystropha* Pritchard, 1904.

Bankivia howitti Pritchard, 1903.

Bankivia howitti G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 334, pl. 18, fig. 1, September, 1904.

M.U.G.D. No. 1817. HOLOTYPE, figured by Pritchard, loc. cit., 1904.

Lower Pliocene (Kalimnan).

("Sandy clays of Jimmy's Point, Gippsland" (Pritchard, loc. cit., p. 334, 1904) = Jemmy's Point, Kalimna, Gippsland Lakes, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Cantharidus serratulus Pritchard, 1904.

Cantharidus serratulus G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 331, pl. 19, figs. 5, 6, September, 1904.

M.U.G.D. No. 1826. SYNTYPE, figured by Pritchard, loc. cit., fig. 5, 1904.

M.U.G.D. No. 1827. SYNTYPE, figured by Pritchard, loc. cit., fig. 6, 1904.

Miocene (Balcombian).

Lower beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Clavella bulbodes (Tate, 1888) :—**Austrolithes bulbodes** (Tate, 1888).

Fusus bulbodes R. Tate, Trans. Roy. Soc. S. Aust., 10, p. 139, pl. 7, fig. 8, 1888.

Clavilithes bulbodes R. Tate, Journ. Roy. Soc. N.S. Wales, 27, p. 170, 1894.

Clavella bulbodes Tate: G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 14 (1), p. 48, 1901. G. B. Pritchard, *ibid.*, 17 (1), p. 320, pl. 18, figs. 2, 3, 1904.

M.U.G.D. No. 1800. HYPOTYPE, figured by Pritchard, loc. cit., fig. 3, 1904.

M.U.G.D. No. 1801. HYPOTYPE, juvenile, figured by Pritchard, loc. cit., fig. 2, 1904.

Miocene (Balcombian).

"Clays of the Old Cement Works, Balcombe's Bay" (Pritchard, loc. cit., p. 322, 1904), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Clavella platystropha Pritchard, 1904: — **Austrolithes platystropha** (Pritchard, 1904).

Clavella platystropha G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 322, pl. 18, figs. 4, 5, September, 1904.

M.U.G.D. No. 1802. Holotype, figured by Pritchard, loc. cit., fig. 4, 1903.

M.U.G.D. No. 1803. Paratype, juvenile, figured by Pritchard, loc. cit., fig. 5, 1903.

Miocene (Balcombian).

"Lower Beds of Muddy Creek sections near Hamilton, Western Victoria" (Pritchard, loc. cit., p. 323, 1904).

Purchased from Dr. G. B. Pritchard, 11.10.39.

Collonia geelongensis Pritchard, 1904.

Collonia geelongensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 330, pl. 18, figs. 8, 9, September, 1904.

M.U.G.D. No. 1819. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

"Clays over Polyzoal Rock, Filter Quarries, Batesford, near Geelong" (Pritchard, loc. cit., p. 330, 1904), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Collonia otwayensis Pritchard, 1904.

Collonia otwayensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 331, pl. 18, figs. 6, 7, September, 1904.

M.U.G.D No. 1818. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Janjukian).

"Clays and sandy clays of the Cape Otway section near Point Flinders" (Pritchard, loc. cit., p. 331, 1904), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Columbella approximans Pritchard, 1904.

Columbella approximans G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 325, pl. 18, figs. 12, 13, September, 1904.

M.U.G.D. No. 1821. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

"Clays of the Old Cement Works, Balcombe's Bay, Mornington" (Pritchard, loc. cit., p. 325, 1904), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Columbella balcombensis Pritchard, 1904.

Columbella clathrata R. Tate MS.

Columbella balcombensis G. B. Pritchard, Proc. Roy. Soc Vic., n.s., 17 (1), p. 324, pl 18, figs. 10, 11, September, 1904.

M.U.G.D. No. 1820. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

"Clays of the Old Cement Works, Balcombe's Bay" (Pritchard, loc. cit., p. 324, 1904), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Epideira selwyni (Pritchard, 1904).

See *Pleurotoma selwyni* Pritchard, 1904.

Epideira selwyni suppressa Finlay, 1927.

See *Pleurotoma selwyni* var. *laevis* Pritchard, 1904.

Ericusa fulgetroides (Pritchard, 1898).

See *Voluta fulgetroides* Pritchard, 1898.

Eutrochus fontinalis Pritchard, 1904.

Eutrochus fontinalis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 333, pl. 19, fig. 9, September, 1904.

M.U.G.D. No. 1816. Holotype (imperfect), figured by Pritchard, loc. cit., 1904.

Miocene (Janjukian).

"Lower beds of the Spring Creek series, or Bird Rock Bluff, near Geelong" (Pritchard, loc. cit., p. 334, 1904) = Lower beds, Bird Rock cliffs, near Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Imperator johnstoni (Pritchard, 1896).

See *Astralium (Imperator) johnstoni* Pritchard, 1896.

Latirofusus cingulata Pritchard, 1896.

Latirofusus cingulata G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 83, pl. 2, figs. 5, 6, April, 1896.

M.U.G.D. No. 1814. Holotype, figured by Pritchard, loc. cit., 1896.

Miocene (Janjukian).

"Lower beds of the lower eocene series of Spring Creek, near Geelong, Victoria" (Pritchard, loc. cit., p. 84, 1896) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Lophiotoma murrayana (Pritchard, 1904).

See *Pleurotoma murrayana* Pritchard, 1904.

Murex wallacei Pritchard, 1898.

Murex wallacei G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 11 (1), p. 104, pl. 7, fig. 3, September, 1898.

M.U.G.D. No. 1831. Holotype, figured by Pritchard, loc. cit., 1898.

Miocene (Balcombian).

"Eocene clays of Mornington" (Pritchard, loc. cit., p. 105, 1898).

Coll. W. Wallace. Purchased from Dr. G. B. Pritchard, 11.10.39.

Niso kimberi Pritchard, 1906.

Niso kimberi G. B. Pritchard, Vic. Naturalist, 23 (6), p. 119, 4th October, 1906.

M.U.G.D. No. 1873. Holotype, unfigured.

Miocene (Janjukian).

"Lower beds of the Aldinga series, South Australia" (Pritchard, loc. cit., p. 119, 1903) = Lower beds, Aldinga Bay, South Australia.

Coll. W. J. Kimber. Purchased from Dr. G. B. Pritchard, 11.10.39.

Notopeplum liratum (Johnston, 1880).

See *Voluta lirata* Johnston, 1880.

Pleurotoma granti Pritchard, 1904:—**Apiotoma granti** (Pritchard, 1904).

Pleurotoma granti G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 336, pl. 19, fig. 3, September, 1904.

Apiotoma granti Pritchard: A. W. B. Powell, Bull. Auck. Inst. Mus., 2, p. 65, 1942 [as *Pleurotoma granti* Pritchard]. A. W. B. Powell, Rec. Auck. Inst. Mus., 3 (1), p. 21, 1944.

M.U.G.D. No. 1807. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

Lower beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Pleurotoma murrayana Pritchard, 1904:—**Lophiotoma murrayana** (Pritchard, 1904).

Pleurotoma murrayana G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 335, pl. 19, fig. 10, September, 1904.

Lophiotoma murrayana (Pritchard, 1904): A. W. B. Powell, Rec. Auck. Inst. Mus., 3 (1), p. 9, 1944.

M.U.G.D. No. 1824. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Barwonian; probably Balcombian).

"River Murray Cliffs, near Morgan" (Pritchard, loc. cit., p. 336, 1904), South Australia. The label on the original box states "River Murray Cliffs near Mannum", which is evidently a *lapsus*.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Pleurotoma selwyni Pritchard, 1904:—**Epideira selwyni** (Pritchard, 1904).

Pleurotoma selwyni G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 326, pl. 19, fig. 1, September, 1904.

Turris selwyni (Pritchard, 1904): A. W. B. Powell, Rec. Auck. Inst. Mus., 3 (1), p. 8, 1944.

M.U.G.D. No. 1822. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

Lower beds of Muddy Creek, near Hamilton, Western Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Pleurotoma selwyni var. **laevis** Pritchard, 1904:—**Epideira selwyni suppressa** Finlay, 1927.

Pleurotoma selwyni variety *laevis* G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 328, pl. 19, fig. 2, September, 1904. Not *Pleurotoma laevis* Bellardi, M. R. Acc. Sci. Torino, [2] 9, p. 542, 1848. Nor *Pleurotoma laevis* F. W. Hutton, Cat. Marine Moll. N.Z., p. 12, 1873 (=*Splendrillia aoteana* H. J. Finlay, nom. nov., Trans. N.Z. Inst., 61 (1), p. 47, 1930).

Epideira selwyni suppressa H. J. Finlay, nom. nov., Trans. N.Z. Inst., 57, p. 516, 19th January, 1927.

Epidirona suppressa (Finlay, 1927): A. W. B. Powell, Rec. Auck. Inst. Mus., 3 (1), p. 16, 1944.

M.U.G.D. No. 1823. Holotype, figured by Pritchard, loc. cit., 1904.

Miocene (Balcombian).

Lower beds of Muddy Creek, near Hamilton, Western Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Obs.—Finlay, loc. cit., 1927, cites as another homonym *Pleurotoma laevis* Bell, 1890, for which he provides *Raphitoma belliana*, nom. nov. But at the reference cited (Rept. Brit. Assoc. Adv. Sci. 60th Meeting (Leeds, 1890), p. 410, 1891) A. Bell includes in a list *Pleurotoma laevis* (n. sp.), which is a *nomen nudum*, next appearing in the synonymy of *Raphitoma laevis* (A. Bell) F. W. Harmer, Plioc. Moll. Gt. Britain, 2 (1), Palaeontogr. Soc., Lond., 72, for 1918, p. 523, pl. 47, fig. 10, December, 1920. This latter combination, which must be cited as *Raphitoma laevis* Harmer, 1922, does not clash with *Pleurotoma laevis* and therefore *Raphitoma belliana* Finlay, 1927, falls in its synonymy.

Pleurotomaria bassi Pritchard, 1903.

Pleurotomaria bassi Pritchard, Proc. Roy. Soc. Vic., n.s., 16 (1), p. 85, pl. 13, figs. 1, 2, September, 1903.

M.U.G.D. No. 1797. Holotype, figured by Pritchard, loc. cit., 1903.

Miocene (Janjukian).

" Basal horizon of the Table Cape Beds, Tasmania, in coarse ferruginous grits " Pritchard, loc. cit., p. 86, 1903).

Purchased from Dr. G. B. Pritchard, 11.10.39.

Pleurotomaria tertiaria McCoy, 1876.

Pleurotomaria Tertiaria F. McCoy, Prodromus Palaeont. Vic., decade 3, p. 23, pl. 25, figs. 1, 1*a*, 1*b*, 1876.

Pleurotomaria tertiaria McCoy: G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 16 (1), p. 83, pl. 14, figs. 1-4, 1903.

M.U.G.D. No. 1798. Hypotype, figured by Pritchard, loc. cit., figs. 1-3, 1903.

Miocene (Barwonian, probably Balcombian).

" ? Corio Bay or Lower Moorabool Valley " (Pritchard, loc. cit., p. 91, 1903) Victoria. The specimen (No. 1798) when received from Dr. Pritchard was in a box marked " O.A.H. Geelong ", which refers to Orphanage Hill, Fyansford, near Geelong, Victoria, a locality in the Lower Moorabool Valley.

Coll. Rev. A. W. Cresswell. Purchased from Dr. G. B. Pritchard, 11.10.39.

Pterospira gatliffi (Pritchard, 1898).

See *Voluta gatliffi* Pritchard, 1898.

Pterospira stephensi (Johnston, 1880).

See *Voluta stephensi* Johnston, 1880.

Solutofusus carinatus Pritchard, 1898.

Solutofusus carinatus G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 11 (1), p. 102, pl. 7, figs. 1, 1*a*, 2, September, 1898.

M.U.G.D. No. 1829. Holotype, figured by Pritchard, loc. cit., figs. 1, 1*a*, 1898.

M.U.G.D. No. 1830. Paratype, figured by Pritchard, loc. cit., fig. 2, 1898.

Miocene (Balcombian).

" Eocene clays of Balcombe's Bay, Mornington " (Pritchard, loc. cit., p. 103, 1898), Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Tentaculites matlockiensis Chapman, 1904.

Tentaculites matlockiensis F. Chapman, Proc. Roy. Soc. Vic., n.s., 16 (2), p. 338, pl. 31, figs. 1-3, 5, March, 1904. E. D. Gill, *ibid.*, 53 (1), p. 150, pl. 4, figs. 4, 5, 1941.

M.U.G.D. No. 1734. Hypotype, internal cast, figured by Gill, loc. cit., fig. 4, 1941.

M.U.G.D. No. 1735. Counterpart of hypotype, external mould (counterpart of No. 1734), unfigured.

"Silurian (Jordanian)" (Gill, loc. cit., p. 161, 1941) = Upper Silurian (Tanjilian).

Cutting on west bank of Muddy Creek (near McMahon's Creek) on south side of Warburton-Wood's Point Road, Victoria.

Presented by Rev. E. D. Gill, 24.5.41.

Tremanotus pritchardi Cresswell, 1893:—**Trematonotus pritchardi** (Cresswell, 1893).

Tremanotus [*sic*] *pritchardi* A. W. Cresswell, Proc. Roy. Soc. Vic., n.s., 5, p. 42 and addenda slip opposite p. 38, pl. 8, fig. 1 (3 figs.), May, 1893.

M.U.G.D. No. 1666. Holotype, figured by Cresswell, loc. cit., 1893.

M.U.G.D. No. 1667. Counterpart of holotype, part of external mould, unfigured.

Lower Devonian (Yeringian).

Cave Hill Quarry, Lilydale, Victoria. The type material is stated by Dr. Pritchard (personal communication, 1939) to be from the south face of the quarry (Mitchell's quarry).

Purchased from Dr. G. B. Pritchard, 11.10.39.

Trematonotus pritchardi (Cresswell, 1893).

See *Tremanotus pritchardi* Cresswell, 1893.

Trophon selwyni Pritchard, 1896.

Trophon selwyni G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 79, pl. 2, fig. 7, April, 1896.

M.U.G.D. No. 1815. Holotype, figured by Pritchard, loc. cit., 1896.

Miocene (Janjukian).

"Lower beds of the lower eocene of Spring Creek, near Geelong, Victoria" (Pritchard, loc. cit., p. 81, 1896) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Turbo hamiltonensis Pritchard, 1904:—**Turbo (Subninella) grangensis** Pritchard, 1906.

Turbo paucigranosa R. Tate MS.: J. Dennant, Trans. Roy. Soc. S. Aust., 11, p. 48, 1889 (list name).

Turbo hamiltonensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 17 (1), p. 329, pl. 19, fig. 4, September, 1904. Not *Turbo hamiltonensis* G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 274, pl. 8, fig. 3*a-c*, 1897.

Turbo grangensis G. B. Pritchard, nom. mut., Vic. Naturalist, 23 (6), p. 117, 4th October, 1906. F. Chapman, Proc. Roy. Soc. Vic., n.s., 35 (1), p. 10, pl. 2, figs. 13, 14, 1922.

M.U.G.D. No. 1808. Holotype, figured by Pritchard, loc. cit., 1904.

Lower Pliocene (Kalimnan).

"Upper beds of the Grange Burn, near Hamilton, Western Victoria" (Pritchard, loc. cit., p. 330, 1904).

Purchased from Dr. G. B. Pritchard, 11.10.39.

Turbo (Subninella) grangensis Pritchard, 1906.

See *Turbo hamiltonensis* Pritchard, 1904.

Voluta fulgetroides Pritchard, 1898:—**Ericusa fulgetroides** (Pritchard, 1898).

Voluta fulgetroides G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 11 (1), p. 105, pl. 7, fig. 4, September, 1898.

M.U.G.D. No. 1804. HOLOTYPE, figured by Pritchard, loc. cit., 1898.

Lower Pliocene (Kalimnan).

"Miocene beds of Muddy Creek" (Pritchard, loc. cit., p. 106, 1898) = Upper beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta gatliffi Pritchard, 1898:—**Pterospira gatliffi** (Pritchard, 1898).

Voluta gatliffi G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 11 (1), p. 108, pl. 8, fig. 6, September, 1898.

M.U.G.D. No. 1805. HOLOTYPE, figured by Pritchard, loc. cit., 1898.

Miocene (Balcombian).

"Eocene beds of Muddy Creek, Western Victoria" (Pritchard, loc. cit., p. 109, 1898) = Lower beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta halli Pritchard, 1896.

Voluta halli G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 101, pl. 2, figs. 1-3, April, 1896. G. B. Pritchard, *ibid.*, 26 (1), p. 198, 1913.

M.U.G.D. No. 1789. HOLOTYPE, figured by Pritchard, loc. cit., fig. 1, 1896.

Miocene (Janjukian).

"Lower Eocene beds at Spring Creek, near Geelong" (Pritchard, loc. cit., p. 102, 1896) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

M.U.G.D. No. 1790. PARATYPE, juvenile, figured by Pritchard, loc. cit., fig. 2, 1898.

M.U.G.D. No. 1791. PARATYPE, juvenile, figured by Pritchard, loc. cit., fig. 3, 1898.

Miocene (Balcombian).

"Eocene clays of Curlewis, Bellarine Peninsula, Victoria" (Pritchard, loc. cit., p. 102, 1896).

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta hamiltonensis Pritchard, 1898.

Voluta hamiltonensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 11 (1), p. 107, pl. 8, fig. 5, September, 1898.

M.U.G.D. No. 1832. HOLOTYPE, figured by Pritchard, loc. cit., 1898.

Miocene (Balcombian).

"Eocene beds of Muddy Creek, Western Victoria" (Pritchard, loc. cit., p. 108, 1898) = Lower beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta lirata Johnston, 1880:—**Notopeplum liratum** (Johnston, 1880).

"*Voluta lirata* R. M. Johnston," Pap. Roy. Soc. Tas. for 1879, p. 37, 1880. Not *Voluta lirata* Johnston: R. Tate, Trans. Roy. Soc. S. Aust., 11, p. 130, pl. 2, fig. 4, 1889; nor G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 103, pl. 4, fig. 12, 1897 (=*V. costellifera* Tate, var.).

Voluta allporti R. M. Johnston, Geol. Tas., pl. 30, fig. 10, 1888. Not *Voluta allporti* R. M. Johnston, Pap. Roy. Soc. Tas. for 1879, p. 35, 1880.

Voluta lirata Johnston: G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 26 (1), p. 197, pl. 20, figs. 7, 8, 1913.

M.U.G.D. No. 1795. Hypotype, figured by Pritchard, loc. cit., 1913.

Miocene (Janjukian).

"Table Cape Beds, Tasmania" (Pritchard, loc. cit., p. 192, 1913) = Table Cape, near Wynyard, Tasmania. The "Table Cape" beds are actually at the Fossil Bluff, west of the mouth of the Inglis River at Wynyard. The colour and matrix suggest the lower or "Crassatella" bed at this locality.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta pueblensis Pritchard, 1898.

Voluta pueblensis G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 11 (1), p. 109, pl. 8, fig. 7, September, 1898.

M.U.G.D. No. 1806. Holotype, figured by Pritchard, loc. cit., 1898.

Miocene (Janjukian).

"Lower horizon of the Eocene beds of Spring Creek, south of Geelong" (Pritchard, loc. cit., p. 110, 1898. Erroneously given as "Muddy Creek" on explanation to plate, p. 111, 1898) = Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta spenceri Pritchard, 1896.

Voluta spenceri G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 98, pl. 4, figs. 1, 2, April, 1896. G. B. Pritchard, *ibid.*, 26 (1), p. 198, 1913.

M.U.G.D. No. 1813. Paratype, imperfect apical portion, figured by Pritchard, loc. cit., fig. 2, 1896.

Miocene (Balcombian).

"Eocene clays of Curlewis, Bellarine Peninsula, Victoria."

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta stephensi Johnston, 1880:—**Pterospira stephensi** (Johnston, 1880).

Voluta stephensi R. M. Johnston, Pap. Roy. Soc. Tas. for 1879, p. 35, 1880. G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 94, 1896. G. B. Pritchard, *ibid.*, 26 (1), p. 195, pl. 21, figs. 3, 4, September, 1913.

M.U.G.D. No. 1796. Hypotype, figured by Pritchard, *loc. cit.*, 1913.

Miocene (Janjukian).

"Table Cape Beds, Tasmania" (Pritchard, loc. cit., p. 192, 1913) = Table Cape, near Wynyard, Tasmania. Colour and matrix definitely allocate it to the lower or "Crassatella" bed at this, the type locality.

Voluta weldii T. Woods, 1876:—**Aulica weldii** (T. Woods, 1876).

Voluta Weldii J. E. T. Woods, Pap. Roy. Soc. Tas. for 1875, p. 24, pl. 1, fig. 2, 1876. R. M. Johnston, Geol. Tas., pl. 30, figs. 6-6*b* (*non* fig. 7), 1888. R. Tate, Trans. Roy. Soc. S. Aust., 11, p. 134, 1889. G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 8, p. 93, 1896.

Voluta (Aulica) weldi T. Woods: G. F. Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 102, 1897.

Voluta (Aulica) Weldii T. Woods: R. Tate, Journ. Roy. Soc. N.S. Wales, 31, p. 386, 1898.

Voluta weldii T. Woods: G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 26 (1), p. 193, pl. 20, fig. 1, 1913.

M.U.G.D. No. 1792. Hypotype, figured by Pritchard, loc. cit., 1913.

Miocene (Janjukian).

"Table Cape Beds, Tasmania" (Pritchard, loc. cit., p. 192, 1913) = Table Cape, near Wynyard, Tasmania. The matrix suggests the upper or Turritella bed at this, the type locality.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Voluta weldii var. **angustior** Pritchard, 1913:—**Aulica weldii angustior** (Pritchard, 1913).

Voluta weldii variety *angustior* G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 26 (1), p. 194, pl. 20, figs. 4, 5, September, 1913.

M.U.G.D. No. 1794. Holotype, figured by Pritchard, loc. cit., 1913.

"Table Cape Beds, Tasmania" (Pritchard, loc. cit., p. 192, 1913) = Table Cape, near Wynyard, Tasmania. Colour and matrix suggest the lower or "Crassatella" bed at this locality.

Voluta weldii var. **intermedia** Pritchard, 1913:—**Aulica weldii intermedia** (Pritchard, 1913)

Voluta weldii variety *intermedia* G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 26 (1), p. 193, pl. 20, figs. 2, 3, September, 1913.

M.U.G.D. No. 1793. Holotype, figured by Pritchard, loc. cit., 1913.

Miocene (Balcombian).

Lower beds, Muddy Creek, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

CEPHALOPODA.

Aturoidea distans Teichert, 1943.

Aturoidea distans C. Teichert, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 260, text fig. 1, pl. 11, figs. 1-4, October, 1943.

M.U.G.D. No. 1860. Holotype, figured by Teichert, loc. cit., text fig. 1, pl. 11, fig. 1, 1943

M.U.G.D. No. 1861. Paratype, figured by Teichert, loc. cit., pl. 11, figs. 2, 3, 1943.

M.U.G.D. No. 1862. Paratype, figured by Teichert, loc. cit., pl. 11, fig. 4, 1943.

Eocene.

Grit band 30-40 feet above Jurassic-Tertiary unconformity, second point north-west of Pebble Point, south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

Nautilus geelongensis Foord. 1891.

Nautilus geelongensis A. H. Foord, Cat. Foss. Cephal. Brit. Mus., pt. 2, p. 332, figs. 69 *a-c* (woodcut), 1891. F. Chapman, Proc. Roy. Soc. Vic., n.s., 27 (2), p. 354. pl. 4, figs. 7-9, 1915. C. Teichert, *ibid.*, 55 (2), p. 263, text fig. 4 (p. 262), 1943.

M.U.G.D. No. 1863. Hypotype, suture figured by Teichert, loc. cit., 1943.

Upper Miocene (Cheltenhamian).

"Cheltenham" = Upper beds, Beaumaris, Victoria. The specimen is an internal cast in brown sandstone.

Purchased from T. Worcester.

Nautilus victorianus Teichert, 1943.

Nautilus victorianus C. Teichert, Proc. Roy. Soc. Vic., n.s., 55 (2), p. 262, text fig. 2. pl. 11, figs. 5-7, October, 1943.

M.U.G.D. No. 1864. Holotype, figured by Teichert, loc. cit., 1943.

Eocene.

Grit band 30-40 feet above Jurassic-Tertiary unconformity, second point north-west of Pebble Point, south-east of Princetown, Victoria.

Coll. Jan., 1942, and pres. G. Baker, Jan., 1943.

Tetrabelus macgregori Glaessner, 1945.

Tetrabelus macgregori M. F. Glaessner, Proc. Roy. Soc. Vic., n.s., 56 (2), p. 160, pl. 6, figs. 12*a*, *b*, 1945.

M.U.G.D. No. 1876. Holotype, figured by Glaessner, *loc cit.*, 1945.

Cretaceous (Purari Formation: Aptian-Albian).

Paw Creek, Purari River, Papua.

Coll. S. W. Carey and pres. M. F. Glaessner, 29.9.44.

CIRRIPEDIA.

Lepas pritchardi T. S. Hall, 1902.

Lepas pritchardi T. S. Hall, Proc. Roy. Soc. Vic., n.s., 15 (1), p. 83, pl. 11, figs. 11-13, August, 1902.

M.U.G.D. No. 1809. Paratype (?), unfigured.

Miocene (Janjukian).

"Spring Creek" (Hall, loc. cit., p. 84, 1902) = Bird Rock Cliffs, near Spring Creek, Torquay, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Obs.—This specimen is mentioned by Hall in his original description but it is not specifically stated to be a supplementary type. The "type" (i.e., holotype) is from Waurn Ponds and is now in the National Museum, Melbourne.

PHYLLOCARIDA.

Hymenocaris ornata Sherrard, 1930.

Hymenocaris ornata K. Sherrard, Proc. Roy. Soc. Vic., n.s., 42 (2), p. 136, pl. 11, figs. 1-3, 13th March, 1930.

M.U.G.D. No. 993. HOLOTYPE, figured by Sherrard, loc. cit., 1930.

M.U.G.D. No. 994. COUNTERPART OF HOLOTYPE No. 993.

Lower Ordovician (Lancefieldian, Zone La 2).

Quarry, Allot. 56, Parish of Goldie, near Lancefield, Victoria.

Coll. Sept., 1923 and pres. Mrs. K. Sherrard, 12.12.29.

MEROSTOMATA.

Hemiaspis tunnecliffei Chapman, 1932.

Hemiaspis tunnecliffei F. Chapman, Proc. Roy. Soc. Vic., n.s., 44 (1), p. 102, pl. 14, figs. 4, 5, 29th February, 1932.

M.U.G.D. No. 1201. HOLOTYPE, figured by Chapman, loc. cit., 1932, where the register number is erroneously stated to be 1801.

Upper Silurian (Melbournian).

"Road Cutting, Studley Park, Kew, Melbourne, Victoria" (Chapman, loc. cit., 1932). In the Register of Fossils in Melbourne University Geology Department, the locality is given as "Track to Pumping Station (? Monograptus bed), near Johnston Street Bridge, Studley Park, Victoria."

Presented by Master T. Tunnecliffe, jun., 8.7.31.

PISCES.

Antiarchan fish, ?genus.

Antiarchan, genus indet., E. S. Hills, Proc. Roy. Soc. Vic., n.s., 48 (2), p. 163, text-fig. 3, 1st June, 1936.

M.U.G.D. No. 1590. FIGURED PLASTER CAST, posterior median dorsal plate, figured by Hills, loc. cit., 1936.

Middle Devonian.

Gilberton District, Queensland.

Presented (plaster cast) by Dr. F. W. Whitehouse, 1935, the original being in his possession.

Bothriolepis gippslandiensis Hills, 1929.

Bothriolepis gippslandiensis E. S. Hills, Proc. Roy. Soc. Vic., n.s., 41 (2), p. 195, text fig. 2, No. 4 (p. 196), pl. 18, fig. 8, April, 1929. E. S. Hills, Geol Mag., 68 (5), p. 214, text figs. 5 (p. 215), 6, Nos. 1-3 (p. 218), 7, Nos. 1, 3 (p. 220), May, 1931.

M.U.G.D. No. 776. HOLOTYPE, specimen C.B., median occipital plate, figured by Hills, loc. cit., pl. 18, fig. 8, 1929.

M.U.G.D. No. 789. PARATYPE, specimen C.L., external marginal plate, figured by Hills, loc. cit., text fig. 2, No. 6, 1929.

M.U.G.D. No. 1882. Hypotype, specimen T22*a*, anterior ventro-lateral plate, figured by Hills, loc. cit., pl. 11, fig. 5, 1931.

M.U.G.D. No. 1883. Counterpart of Hypotype No. 1882.

M.U.G.D. No. 1884. Hypotype, specimen T10*b*, pectoral appendage, figured by Hills, loc. cit., pl. 11, fig. 2, 1931.

M.U.G.D. No. 1885. Counterpart of Hypotype No. 1884.

M.U.G.D. No. 1886. Hypotype, specimen T28*a*, left posterior dorso-lateral plate, figured by Hills, loc. cit., pl. 11, fig. 3, 1931.

M.U.G.D. No. 1887. Hypotype, specimen T37*a*, anterior median dorsal plate, figured by Hills, loc. cit., pl. 11, fig. 6, 1931.

M.U.G.D. No. 1888. Hypotype, specimen T38*a*, anterior median dorsal plate, figured by Hills, loc. cit., pl. 11, fig. 4, 1931.

M.U.G.D. No. 1889. Counterpart of Hypotype No. 1888.

M.U.G.D No. 1890. Counterpart of Hypotype No. 1889.

M.U.G.D. No. 1891. Hypotype, specimen T36*a*, anterior median dorsal plate, figured (as median section) by Hills, loc. cit., text fig. 7, No. 1, 1931.

M.U.G.D. No. 1892. Counterpart of Hypotype No. 1887.

M.U.G.D. No. 1893. Plaster Cast of counterpart No. 1892.

M.U.G.D. No. 1894. Hypotype, specimen T8*a*, median occipital plate, and counterpart (No. 1895), specimen T8*b*, described by Hills, loc. cit., pp. 217-8, 1931.

M.U.G.D. No. 1896. Hypotype, specimen 1A, premedian plate, upper surface, and counterpart (No. 1897), specimen 1B, lower surface, described by Hills, loc. cit., pp. 218-9, 1931.

M.U.G.D. No. 1898. Hypotype, incomplete posterior median dorsal plate, described by Hills, loc. cit., p. 221, 1931, and anterior median dorsal plate.

M.U.G.D. No. 1899. Hypotype, specimen T27*a*, posterior dorso-lateral plate, upper surface, and counterpart (No. 1900), specimen T 27*b*, lower surface, described by Hills, loc. cit., p. 221, 1931.

M.U.G.D. No. 1901. Hypotype, specimen T34*a*, anterior dorso-lateral plate, upper surface, and counterpart (No. 1902), specimen T34*b*, lower surface, described by Hills, loc. cit., p. 221, 1931.

M.U.G.D. No. 1903. Hypotype, specimen T34*c*, posterior ventro-lateral plate, upper surface, described by Hills, loc. cit., p. 221, 1931.

M.U.G.D. No. 1904. Hypotype, specimen T26*a*, median ventral plate, upper surface, and counterpart (No. 1905), specimen T26*b*, lower surface, described by Hills, loc. cit., p. 221, 1931.

M.U.G.D. No. 1906. Hypotype, specimen T16*a*, brachial plates, upper surface, and counterpart (No. 1907), specimen T16*b*, lower surface, described by Hills, loc. cit., pp. 221-2, 1931.

Upper Devonian.

Blue Hills, near Taggerty, Victoria.

Coll. and pres. E. S. Hills, 20.2.29.

Bothriolepis sp.

Bothriolepis sp.: E. S. Hills, Proc. Roy. Soc. Vic., n.s., 48 (2), p. 165, text fig. 5, pl. 12 (p. 170), fig. 3, June, 1936.

M U.G.D. No. 1588. Figured specimen, right pectoral fin, figured by Hills, loc. cit., pl. 12, fig. 3, 1936.

M.U.G.D. No. 1589. Figured specimen, ventro-lateral plate, figured by Hills, loc. cit., text fig. 5, 1936.

Upper Devonian.

Allotment 75A, Parish of Loyola, South Blue Range, near Mansfield, Victoria.

Coll. H. B. Hauser, 1933.

Diodon connewarrensis Chapman and Pritchard, 1907.

Diodon connewarrensis F. Chapman and G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 20 (1), p. 69, pl. 8, figs. 8-10, August, 1907. F. Chapman and F. A. Cudmore, *ibid.*, 36 (2), p. 147, 1924.

M.U.G.D. No. 1838. Holotype, spine, figured by Chapman and Pritchard, loc. cit., 1907.

Miocene (Balcombian).

Point Campbell clays, Lake Connewarre, near Geelong, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Diodon formosus Chapman and Pritchard, 1907.

Diodon formosus F. Chapman and G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 20 (1), p. 66, pl. 6, figs. 1-3; pl. 7; pl. 8, figs. 1-7, August, 1907. F. Chapman, Australasian Fossils, pp. 270, 271, fig. 131*f*, 1914. F. Chapman and F. A. Cudmore, Proc. Roy. Soc. Vic., n.s., 36 (2), p. 146, 1922.

M.U.G.D. No. 1837. Paratype, jaw of young example, figured by Chapman and Pritchard, loc. cit., pl. 8, fig. 4, 1907.

Upper Miocene (Cheltenhamian) [Beaumaris] or Lower Pliocene (Kalimnan) [Grange Burn].

Beaumaris, Port Phillip, Victoria (*fide* paper label with specimen, in Chapman's pencilled writing). Explanation to plate states fig. 4 (of which this is undoubtedly the original) to be from Grange Burn. The black colour of the specimen favours Grange Burn but is not decisive.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Dipterus microsoma (Hills, 1929).

See *Eoctenodus microsoma* Hills, 1929.

Edaphodon sweeti Chapman and Pritchard, 1907.

Edaphodon sweeti F. Chapman and G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 20 (1), p. 61, pl. 5, figs. 4-6, August, 1907. F. Chapman and F. A. Cudmore, *ibid.*, 36 (2), p. 141, pl. 11, figs. 38, 39, 1924.

M.U.G.D. No. 1834. Syntype, left palatine tooth, figured by Chapman and Pritchard, loc. cit., fig. 6, 1907.

Upper Miocene (Cheltenhamian).

Beaumaris, Port Phillip, Victoria. Though not so labelled, it is almost certainly from the nodule bed at the base of the cliffs.

Purchased from Dr. G. B. Pritchard, 11.10.39.

M.U G.D. No. 1835. SYNTYPE, right vomerine tooth, figured by Chapman and Pritchard, loc. cit., fig. 5, 1907.

Lower Pliocene (Kalimnan).

Grange Burn, near Hamilton, Victoria.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Eoctenodus microsoma Hills, 1929:—**Dipterus microsoma** (Hills, 1929).

Eoctenodus microsoma E. S. Hills, Proc. Roy. Soc. Vic., n.s., 41 (2), p. 193, text fig. 2, Nos. 1-3, 5, 6 (p. 196), pl. 18, figs. 2-7, April, 1929.
Dipterus microsoma (Hills, 1929): E. S. Hills, Geol. Mag., 68 (5), p. 222, May, 1931.

M.U.G.D. No. 773. HOLOTYPE, specimen JFA, parasphenoid, figured by Hills, loc. cit., text fig. 2, No. 5, pl. 18, fig. 5, 1929. Associated is a scale, also figured on pl. 18, fig. 5.

M.U.G.D. No. 770. PARATYPE, specimen C. XVII. *a*, left dentary of young, figured by Hills, loc. cit., pl. 18, fig. 2, 1929.

M.U.G.D. No. 771. PARATYPE, scale, figured by Hills, loc. cit., pl. 18, fig. 3, 1929.

M.U.G.D. No. 772. PARATYPE, specimen C. XVIII. *a*, left cleithrum, figured by Hills, loc. cit., text fig. 2, No. 6, pl. 18, fig. 4, 1929.

M.U.G.D. No. 774. PARATYPE, specimen JC, scale, figured by Hills, loc. cit., pl. 18, fig. 6, 1929.

M.U.G.D. No. 775. PARATYPE, specimen JA, left dentary, figured by Hills, loc. cit., text fig. 2, No. 1, pl. 18, fig. 7, 1929.

M.U.G.D No. 780. PARATYPE, counterpart of paratype No. 771.

M.U.G.D. No. 781. PARATYPE, specimen C. XVIII. *b*, counterpart of paratype No. 772.

M.U G.D. No. 782. PARATYPE, specimen JF, counterpart of holotype No. 773.

M.U.G.D. No. 783. PARATYPE, specimen C iv, counterpart of paratype No. 774.

M.U.G.D. No. 784. PARATYPE, specimen JB1, left dentary.

M.U.G.D. No. 785. PARATYPE, specimen C.MO1, median occipital, figured by Hills, loc. cit., text fig. 2, No. 2, 1929.

M.U.G.D. No. 786. PARATYPE, specimen C.MO2, counterpart of paratype No. 785.

M.U.G.D. No. 787. PARATYPE, specimen JE3, counterpart of paratype No. 784.

M.U.G.D. No. 788. PARATYPE, specimen C.C., clavicle, figured by Hills, loc. cit., text fig. 2, No. 3, 1929.

M.U.G.D. No. 1736. PARATYPE, specimen C xv, scales, fin-bones and rays, described by Hills, loc. cit., p. 195, 1929.

Upper Devonian.

Blue Hills, near Taggerty, Victoria.

Coll. and pres. E. S. Hills, 20.2.29.

Labrodon depressus Chapman and Pritchard, 1907:— **Nummopalatus depressus** (Chapman and Pritchard, 1907.)

Trygon ensifer J. W. Davis (*pars*), Trans. Roy. Dubl. Soc. [2] 4, p. 37, pl. 6, figs. 13, 13*a*, 13*b*, 1888.

Labrodon depressus F. Chapman and G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 20 (1), p. 66, pl. 5, figs. 8, 9, August, 1907. F Chapman, N.Z. Geol. Surv. Pal. Bull. 7, p. 27, pl. 6, figs. 13, 13*a*, 13*b*, 1918.

Nummopalatus depressus Chapman and Pritchard sp.: F. Chapman and F. A. Cudmore, Proc. Roy. Soc. Vic., n.s., 36 (2), p. 143, pl. 11, fig. 43, 1924.

M.U.G.D. No. 1836. Holotype, pharyngeal, figured by Chapman and Pritchard, loc. cit., 1907.

Upper Miocene (Cheltenhamian).

Beaumaris, Port Phillip, Victoria. Though not so stated, it is almost certainly from the nodule bed at this locality.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Myliobatis moorabbinensis Chapman and Pritchard, 1907.

Myliobatis moorabbinensis F. Chapman and G. B. Pritchard, Proc. Roy. Soc. Vic., n.s., 20 (1), p. 60, pl. 5, figs. 1-3, August, 1907. F. Chapman and F. A. Cudmore, *ibid.*, 36 (2), p. 138, 1924. Not "*Myliobatis moorabbinensis* Chapman and Pritchard": F. Chapman and C. J. Gabriel, *ibid.*, 27 (1), p. 57, pl. 10, fig. 57, 1914. F. Chapman, Rec. Geol. Surv. Vic., 3 (4), pp. 339, 353, 355, pl. 76, fig. 57, 1916. F. Chapman, Proc. Roy. Soc. Vic., n.s., 29 (2), p. 139, pl. 9, fig. 8 (= *Myliobatis affinis* F. Chapman and F. A. Cudmore, loc. cit., p. 139, pl. 10, fig. 36, 1924).

M.U.G.D. No. 1833. Paratype, figured by Chapman and Pritchard, loc. cit., fig. 3, 1907.

Upper Miocene (Cheltenhamian).

Beaumaris, Port Phillip, Victoria. Though not so labelled, it is almost certainly from the nodule bed at the base of the cliffs.

Purchased from Dr. G. B. Pritchard, 11.10.39.

Nummopalatus depressus (Chapman and Pritchard, 1907).

See *Labrodon depressus*, Chapman and Pritchard, 1907.

Phyllolepis sp.

Holonema cf. *rugosum* Newberry, 1889 [recte (Claypole, 1886)]: E. S. Hills, Proc. Roy. Soc. Vic., n.s., 41 (2), p. 197, April, 1929. Not *Pterichthys* (?) *rugosus* E. W. Claypole, Proc. Amer. Phil. Soc., 20 p. 666, with fig. 1883 = *Holonema rugosum* J. S. Newberry, Palaeozoic Fishes N. America, p. 92, 1889.

Phyllolepid plates: E. S. Hills, Geol. Mag., 68 (5), p. 212, text figs. 2 (p. 212), 3 (p. 213), May, 1931.

Phyllolepis sp.: E. S. Hills, Proc. Roy. Soc. Vic., n.s., 48 (2), p. 164, text fig. 4, pl. 12 (p. 170), figs. 1, 2, June, 1936.

M.U.G.D. No 790. Figured specimen C.11., lateral plate, described by Hills, loc. cit., 1929, and figured, pl. 12, fig. 2, 1936.

M.U.G.D. No. 791. Figured specimen, plate, Type 1, figured by Hills, loc. cit., text fig. 2, No. 1, 1931.

M.U.G.D. No. 1878. Figured specimen, T.3*a* P, plate, Type 1, figured by Hills, loc. cit., text fig. 2, No. 2, 1931.

M.U.G.D. No. 1879. Counterpart of figured specimen No. 1878.

M.U.G.D. No. 1880. Figured specimen, T.1*a* p, plate, Type 2, figured by Hills, loc. cit., text fig. 2, No. 3, 1931.

Upper Devonian.

Blue Hills, near Taggerty, Victoria.

Coll. and pres. E. S. Hills, 20.2.29.

M.U.G.D. No. 1587. Figured specimen, ventral plate, figured by Hills, loc. cit., text fig. 4, 1936.

Upper Devonian.

Allotment 75A, Parish of Loyola, South Blue Range, near Mansfield, Victoria.

Coll. H. B. Hauser, 1933.

Spaniodon elongatus Pictet, 1850.

Spaniodon elongatus F. J. Pictet, Poiss. Foss. Mt. Liban, p. 35, pl. 6, figs. 1, 2, 1850. F. J. Pictet et A. Humbert, Nouv. Rech. Poiss Foss. Mt. Liban, p. 85, pl. 12, figs. 1, 2, 1866. J. W. Davis, Sci. Trans. Roy. Dublin Soc., [2] 3, p. 588, April, 1887. A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. 4, p. 51, pl. 7, fig. 3, 1901. E. S. Hills, Proc. Roy. Soc. Vic., n.s., 48 (1), p. 50, pl. 2, December, 1935.

M.U.G.D. No. 833. Hypotype, figured by Hills, loc. cit., 1935.

Upper Cretaceous.

Mount Lebanon, Syria.

Purchased from T. Worcester.

CETACEA.

Mammalodon colliveri Pritchard, 1939.

Mammalodon colliveri G. B. Pritchard, Vic. Naturalist, 55 (9), p. 157, text figs. 1 (p. 152), 2 (p. 154), 3 (p. 156), 4, 5 (p. 157), 4th January, 1939.

M.U.G.D. No. 1874. Holotype, skull and lower jaw, figured by Pritchard, loc. cit., 1939.

Miocene (Janjukian).

Lower beds, Bird Rock cliffs, near Spring Creek, Torquay, Victoria. "About 12 ft. above the level of the beach . . . barely a hundred yards around [S.W. of] the Bird Rock corner . . . ." (Pritchard, loc. cit., p. 151, 1939). It is from about a foot above the Spring Creek ledge at its extreme S.W. margin (F. S. Colliver, personal communication, 23.10.44) and is thus from within the Glycymeris beds.

Pres. F. S. Colliver, 19.10.39.

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Hordern, A., 242 Walsh-street, South Yarra, S.E.1 1940
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Keble, R. A., National Museum, Melbourne, C.1 1911
Lang, P. S., B.Agr.Sc., School of Agriculture, University, N.3 .. 1938
Leeper, G. W., M.Sc., Chemistry School, University, Carlton, N.3 .. 1931
Lewis, J. M., D.D.Sc., "Whitethorns," Boundary-road, Burwood, E.13 1921
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Reid, J. S., 498 Punt-road, South Yarra, S.E.1	1924
Richardson, A. E. V., M.A., D.Sc., C.M.G., Council for Scientific and Industrial Research, 314 Albert-street, East Melbourne, C.2	1938
Rivett, Sir David, M.A., D.Sc., Council for Scientific and Industrial Research, 314 Albert-street, East Melbourne, C.2	1911
Rogers, J. Stanley, B.A., M.Sc., University, Carlton, N.3	1924
Rose, F. G. G., Central Weather Bureau, Melbourne, C.1	1944
Sewell, Dr. S. V., 12 Collins-street, C.1	1936
Singleton, F. A., D.Sc., University, Carlton, N.3	1917
Stillwell, F. L., D.Sc., 44 Elphin-grove, Hawthorn, E.2	1910
Sullivan, W., 326 Exhibition-street, Melbourne, C.1	1943
Thomas, Dr. D. J., M.D., 81 Collins-street, Melbourne, C.1 ..	1924
Tiegs, Assoc. Prof. O. W., D.Sc., F.R.S., University, Carlton, N.3	1925
Turner, Professor J. S., M.A., Ph.D., University, Carlton, N.3 ..	1938
Vail, Col. L. E., 485 Bourke-street, Melbourne, C.1	1939
Wadham, Prof. S. M., M.A., Agr. Dip., University, Carlton, N.3 ..	1932
Wettenhall, Dr. Roland R., "Aberfeldie," 557 Toorak-road, S.E.2	1938
White, Dr. A. E. Rowden, 14 Parliament-place, Melbourne, C.2 ..	1938
Withers, R. B., M.Sc., Dip. Ed. Technical School, Brunswick, N.10	1926
Woodruff, Prof. H. A., M.R.C.S., L.R.C.P., M.R.C.V.S., University, Carlton, N.3	1913
Wright, Prof. R. D., D.Sc., M.B., M.S., F.R.A.C.S., F.R.A.C.P., University, Carlton, N.3	1941

Country Members.

Blackburn, Maurice, M.Sc., Fisheries Section, C.S.I.R., Cronulla, N.S.W.	1936
Caddy, Dr. Arnold, "Chandpara," Tylden, Vic.	1924
Caldwell, J. J., Geological Survey Office, Bendigo, Vic.	1930
Crawford, W., Gisborne, Vic.	1920
Currie, Mrs. Ian, Seven Oaks, Euroa	1941
Glaessner, M. F., Ph.D., c/o Mines Department, Melbourne ..	1939
Gloe, C., State Rivers and Water Supply Dept., Eildon Weir ..	1944
Harris, W. J., B.A., D.Sc., Box 34, Warragul, Vic.	1914
Hope, G. B., B.M.E., "Carrical," Hermitage-road, Newtown, Geelong, Vic.	1918
Knight, S. L., B.Sc., State Coal Mines, Wonthaggi	1944
Lawrence, A. O., B.Sc., Dip. For., 509 Ligar-street, Ballarat ..	1931
Mackenzie, H. P., Engr. Commr., R.N. (Ret.), Trawalla, Vic. ..	1924
Mann, S. F., Caramut, Vic.	1922
Quayle, D. S., 33 Gent-street, Ballarat	1939
Thomas, D. E., c/o Geological Survey, Mines Dept., Hobart ..	1929
Trebilcock, Captain R. E., M.C., Wellington-street, Kerang, Vic. ..	1921
White, R. A., B.Sc., School of Mines, Bendigo, Vic.	1918
Yates, H., School of Mines, Ballarat, Vic.	1943

ASSOCIATES.

Aitken, Miss Y., M.Agr.Sc., School of Agriculture, University, Carlton, N.3 1936

Alderman, A. R., M.Sc., Ph.D., F.G.S., Box 4331, G.P.O., Melbourne, C.1 1942

Bage, Miss F., M.Sc., O.B.E., Women's College, Kangaroo Point, Brisbane, Qld. 1906

Baker, G., M.Sc., Geology Department, University, N.3. 1935

Bottoms, E. A., 68 Robinsons-road, Hawthorn, E.2 1943

Brazenor, C. W., National Museum, Russell-street, Melbourne, C.1 1931

Broadhurst, E., M.Sc., 457 St. Kilda-road, Melbourne, S.C.2 .. 1930

Buchanan, Gwynneth, D.Sc., University, Carlton, N.3 1921

Butcher, A. D., M.Sc., Fisheries & Game Dept., 605 Flinders-street, C.1 1936

Butler, L. S. G., No. 3 Los Angeles Court, St. Kilda, S.2 1929

Campbell, J. D., B.Sc., B.M.E., 1327 Burke-road, Kew 1932

Canavan, T., B.Sc., c/o Broken Hill Pty. Ltd., 422 Lit. Collins-street, Melbourne 1936

Carter, A. A. C., "Fairholm," Threadneedle-street, Balwyn, E.8 .. 1927

Chapman, W. D., Major, M.C.E., "Hellas," Stawell-street, Kew, E.4. 1927

Chapple, Rev. E. H., The Manse, Warrigal-road, Oakleigh, S.E.12 .. 1919

Clinton, H. F., Department of Agriculture, Public Offices, C.2 .. 1920

Collins, A. C., 3 Lawrence-street, Newtown, Geelong 1928

Colliver, F. S., 14 McCarron-parade, Essendon, W.5 1933

Condon, M. A., B.Sc., c/o Melbourne and Metropolitan Board of Works, Melbourne 1937

Cook, G. A., M.Sc., B.M.E., 58 Kooyongkoot-road, Hawthorn, E.2 1919

Cookson, Miss I. C., D.Sc., 154 Power-street, Hawthorn, E.2 .. 1916

Coulson, A., M.Sc., 66 Spencer-street, Essendon, W.5 1929

Coulson, A. L., D.Sc., D.I.C., F.G.S., 324 Cotham-road, Kew, E.4 1919

Cowen, Miss Margot E. H., B.Agr.Sc., 2 Leaburn-avenue, S.E.7 .. 1936

Crespin, Miss I., B.A., Mineral Resources Survey, Census Building, City, Canberra, A.C.T. 1919

Croll, I. C. H., M.Sc., 53 The Boulevard, Hawthorn, E.2 1934

Croll, R. D., B.Agr.Sc., 18 Russell-street, Camberwell, E.6 1940

Dadswell, Mrs. Inez W., M.Sc., University, N.3 1939

Deane, Cedric, "Rothley," Sorrett-avenue, Malvern, S.E.4 .. 1923

Dewhurst, Miss Irene, B.Sc., 2 Pine-grove, McKinnon, S.E.14 .. 1936

Dickinson, Miss Jill, B.Sc., State Laboratories, Treasury Gardens 1944

Down, Mrs. Mary R., B.Agr.Sc., 18 Merton-street, Ivanhoe .. 1942

Drummond, F. H., Ph.D., B.Sc., University, Carlton, N.3 1933

Edwards, G. R., B.Sc., Powell-street, St. Arnaud 1937

Elford, F. G., B.Sc., B.Ed., 76 New-street, Brighton, S.5 1929

Elford, H. S., B.E., c/o Tait Publishing Co., 349 Collins-street, Melbourne, C.1 1934

Fawcett, Miss Stella G. M., M.Sc., Box 54, P.O., Omeo 1937

Ferguson, W. H., 37 Brinsley-road, E. Camberwell, E.6 1894

Fisher, Miss E. E., M.Sc., Ph.D., 1 Balwyn-road, Canterbury, E.7 .. 1930
Forster, H. C., B.Agr.Sc., Ph.D., 6 Glendene-avenue, Kew, E.4 .. 1938
Frostick, A. C., 9 Pentland-street, N. Williamstown, W.16 1933
Gabriel, C. J., 293 Victoria-street, Abbotsford, C.1 1922
Gaskin, A. J., M.Sc., 6 Olive-street, E. Malvern, S.E.5 1941
Gillespie, J. M., M.Sc., 22A Mercer-road, Malvern, S.E.3 1941
Gladwell, R. A., 79 Cochrane-street, Elsternwick, S.4 1938
Gordon, Alan, B.Sc., c/o C.S.I.R., Yarra Bank-road, South Melbourne, S.C.4 1938
Goudie, A. G., B.Agr.Sc, Department of Agriculture, Melbourne .. 1941
Grieve, Brian J., M.Sc., Ph.D., D.I.C., Botany School, University, N.3 1929
Gunson, Miss Mary, B.Sc., Zoology Dept., University, N.3 .. 1944
Hanks, W., 7 Lake-grove, Coburg, N.14 1930
Hardy, A. D., 24 Studley-avenue, Kew, E.4 1903
Hauser, H. B., M.Sc., Geology School, University, Carlton, N.3 .. 1919
Head, W. C. E., North-street, Nathalia 1931
Heysen, Mrs. D., P.O. Box 10, Kalangadoo, South Australia .. 1935
Holland, R. A., 526 Toorak-road, Toorak, S.E.2 1931
Holmes, W. M., M.A., B.Sc., 1 Balmoral-avenue, Kew, E.4 .. 1913
Honman, C. S., B.M.E., Melbourne Technical College, 134 Latrobe-street, C.1 1934
Hutchinson, R. C., B.Sc., Dept. of Agriculture, Rabaul 1939
Jack, A. K., M.Sc., 49 Aroona-road, Caulfield, S.E.7 1913
Jacobson, R., M.Sc., 41 Thanet-street, Malvern, S.E.4 1937
Jessep, A. W., B.Sc., M.Ag.Sc., Botanical Gardens, Sth. Yarra, S.E.1 1927
Jona, J. Leon, M.D., M.S., D.Sc., Lister House, 61 Collins-street, Melbourne, C.1 1914
Kenny, J. P. L., B.C.E., Mines Department, Public Offices, C.2 .. 1942
Kilvington, T., M.Sc., Physiology Department, University, N.3 .. 1938
McCance, D., M.Sc., 144 Gatehouse-street, Parkville, N.2 1931
McLennan, Assoc. Prof. Ethel, D.Sc., University, Carlton, N.3 .. 1915
Macpherson, Miss J. Hope, National Museum, Melbourne . 1940
Manning, N., 55 Carroll-crescent, Gardiner, S.E.6 1940
Mellhuish, T. D'A., M.Sc., c/o Elliots & Aust. Drug Pty. Ltd., Terry-street, Rozelle, N.S.W. 1919
Morris, P. F., National Herbarium, South Yarra, S.E.1 1922
Moy, A. F., Melbourne Boys High School, Prospect Hill-road, Canterbury, E.7. 1943
Mushin, Mrs. Rose, 150 Garton-street, North Carlton, N.4 1940
Newman, B. W., B.Sc., Meteorological Bureau, Sydney 1927
Nye, E. E., College of Pharmacy, 360 Swanston-street, Melbourne, C.1 1932
Oke, C., 34 Bourke-street, Melbourne, C.1 1922
Osborne, N., 35 Dorrington-avenue, Glen Iris, S.E.6 1930
Pinches, Mrs. M., 8 Thomas-street, Brunswick, N.10 1943
Prentice, H. J., B.Sc., 218 Esplanade West, Port Melbourne, S.C.7 1936

Pretty, R. B., M.Sc., Technical School, Wonthaggi, Vic. 1922
Raff, Miss J. W., M.Sc., F.R.E.S., University, Carlton, N.3 .. 1910
Rayment, Tarlton, Bath-street, Sandringham, S.8 1929
Richardson, Sidney C., "Fernlea," Upalong-road, Mount Dandenong 1923
Sayce, E. L., B.Sc., A.Inst.P., Research Laboratories, Maribyrnong, W.3 1924
Scott, T. R., M.Sc., B.Ed., 27 Currajong-avenue, Camberwell, E.6 .. 1934
Shaw, Dr. C. Gordon, 57 Clendon-road, Toorak, S.E.2 1931
Sherrard, Mrs. H. M., M.Sc., 43 Robertson-road, Centennial Park, N.S.W. 1918
Singleton, O. P., 126 Anderson-street, South Yarra, S.E.1 1943
Stach, L. W., M.Sc., 250 Riversdale-road, Hawthorn, E.3 .. 1932
Stubbs, G. C., Plant Laboratory, Burnley, E.1 1943
Thomas, G. A., B.Sc., National Museum, Melbourne 1944
Thomas, L. A., B.Sc., c/o Council for Scientific and Industrial Research, Stanthorpe, Queensland 1930
Trüdinger, W., 27 Gerald-street, Murrumbeena, S.E.9 1918
Tubb, J. A., M.Sc., Fisheries Section, C.S.I.R., Cronulla, N.S.W. .. 1936
Vasey, A. J., B.Agr.Sc., Animal Health Laboratory, Parkville, N.3 1937
Vasey, G. H., B.C.E., University, Carlton, N.3 1936
Wade, G. C., B.Agr.Sc., Plant Research Laboratory, Swan-street, Burnley, E.1 1941
Whincup, Mrs. Sylvia, B.Sc., Kerang 1942
Wilcock, A. A., B.Sc., B.Ed., 21 Park-road, Maryborough 1934
Wilson, F. E., F.E.S., 22 Ferncroft-avenue, E. Malvern, S.E.5 .. 1921
Wood, Assoc. Prof. G. L., M.A., Litt. D., University, Carlton, N.3 .. 1933
Woodburn, Mrs. Fenton, 21 Bayview-crescent, Black Rock, S.9 .. 1930
Wunderly, J., D.D.Sc. (Melb.), 7 Victoria-road, Camberwell, E.6 .. 1937

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The names of new genera and species are printed in italics.